Guide to the Geology of the Pontiac-Streator Area, Livingston and La Salle Counties, Illinois

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Field Trip Guidebook 1995C September 9, 1995

Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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Cover photo by W.T. Frankie Geology professor Skip Nelson from Illinois State University studies the crossbedding in Vermilionville Sandstone at the Sandy Ford Nature Preserve, La Salle County.

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Telephone: (217) 244-2427 or 333-4747.

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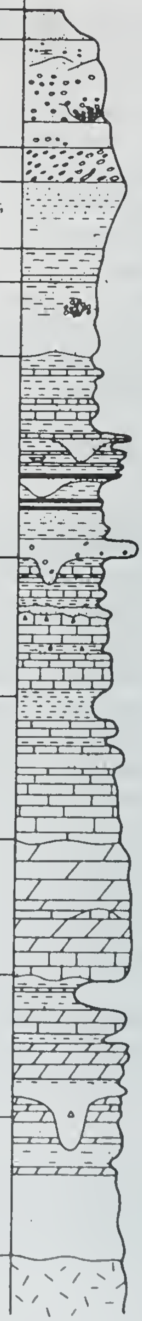
"I give my pledge as an American to save and faithfully to defend from waste the natural resources of my country—its air, soil and minerals, its forests, waters, and wildlife."

From Conservation Pledge at Humiston Woods Nature Center

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0-500'	Holocene	10,000	Recent—alluvium in river valleys
			Pleistocene Glacial Age	1.6 m.	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip
		Tertiary 0-500'	Pliocene	5.3 m.	Chert gravel, present in northern, southern, and western Illinois
			Eocene	36.6 m.	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	57.8 m.	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0-300'		66.4 m.	Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0-3,000' ("Coal Measures")		144 m. / 286 m.	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0-3,500'		320 m.	Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0-1,500'		360 m.	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0-1,000'		408 m.	Principally dolomite and limestone
		Ordovician 500-2,000'		438 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500-3,000'		505 m.	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian		570 m.	Igneous and metamorphic rocks, known in Illinois only from deep wells



Generalized geologic column showing succession of rocks in Illinois.

PONTIAC-STREATOR AREA

The Pontiac-Streator geological science field trip will acquaint you with the *geology**, landscape, and mineral resources for part of Livingston and La Salle Counties, Illinois.

The city of Pontiac is located in north-central Illinois south of the Illinois River. It is approximately 100 miles southwest of the Chicago Loop, 100 miles northeast of Springfield, and 200 miles northeast of St. Louis.

Geologic Framework

Precambrian Era Through several billion years of geologic time, the area surrounding Livingston and La Salle Counties has undergone many changes (see the rock succession column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 35 drill holes have reached deep enough for geologists to collect samples from Precambrian rocks. From these samples, however, we know that these ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. These rocks, which were deeply weathered and eroded when they were exposed at Earth's surface until about 0.6 billion years ago, formed a landscape that was probably quite similar to that of the present-day Missouri Ozarks. We have no rock record in Illinois for the long interval of *weathering* and erosion that lasted from the time the Precambrian rocks were formed until the Cambrian sediments accumulated, but that interval is almost as long as the time from the beginning of the Cambrian to the present.

Geologists seldom see Precambrian rocks in Illinois except as cuttings and cores from drill holes. To determine some of the characteristics of the basement complex, they use various techniques, such as surface mapping, measurements of Earth's gravitational and magnetic fields, and seismic exploration. The evidence indicates that in southernmost Illinois, near what is now the Kentucky-Illinois Fluorspar Mining District, rift valleys like those in east Africa, formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

Paleozoic Era Near the beginning of the Paleozoic Era about 570 million years ago, the rifting stopped and the hilly Precambrian landscape began to sink slowly, on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the several hundred million years of the Paleozoic Era, the area that is now southern Illinois continued to accumulate sediments deposited in the shallow seas that repeatedly covered it. The region continued to sink until at least 15,000 feet of sedimentary strata were deposited. At times during this era the seas withdrew and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, *bedrock* strata range from more than 520 million years (the Cambrian *Period*) to less than 290 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the *formations* were present (the oldest formations are at the bottom right of the column).

The Precambrian basement rocks within the field trip area range from less than 3,000 feet below sea level in northern La Salle County to more that 5,000 feet below sea level in southern Livingston County. The Paleozoic sedimentary strata range from about 3,200 feet thick in northern La Salle County to about 5,900 feet in southern Livingston County.

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*Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

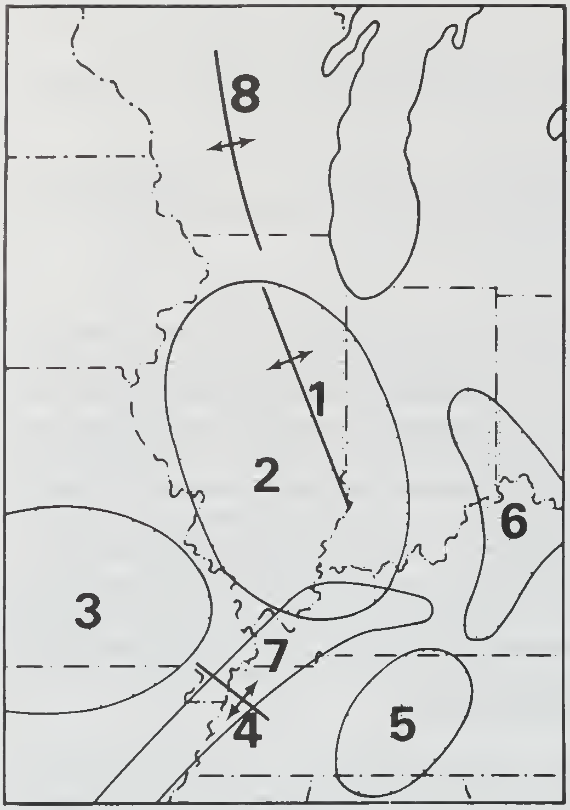


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Pennsylvanian-age bedrock strata consisting of shale, siltstone, sandstone, limestone, coal, and underclay were deposited as sediments in shallow seas and swamps between about 320 and 288 million years ago. They are found immediately beneath a cover of glacial deposits in this area. These rocks are exposed in numerous limestone quarries, abandoned strip coal mines, clay pits, scattered roadcuts, and stream cuts.

Pennsylvanian strata increase in total thickness from 0 feet in northern La Salle County, where the Pennsylvanian rocks have been removed by erosion, to more than 400 feet in southern Livingston County. (See *Depositional History of the Pennsylvanian Rocks* in the supplemental reading at the back of this guidebook for a more complete description of these rocks.)

Structural and Depositional History

As noted previously, midcontinent rift valleys (the Rough Creek Graben and the Reelfoot Rift, figs. 1 and 3) formed during Precambrian tectonic activity. These valleys later filled with sand and gravel that was shed from the adjacent uplands and with limestone that formed in the shallow sea covering the area.

During the Paleozoic Era, sediments accumulated in the seas that covered Illinois and adjacent states. The shallow seas connected with the open ocean to the south during much of the Paleozoic, and the area of southern Illinois was like an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of sediment to accumulate. Earth's thin crust was periodically flexed and warped as stresses built up in places. These worldwide movements caused changes in sea level that resulted in repeated invasions and withdrawals of the seas across the region. Former sea floors were thus periodically exposed to erosion, erasing some sediments from the rock record.

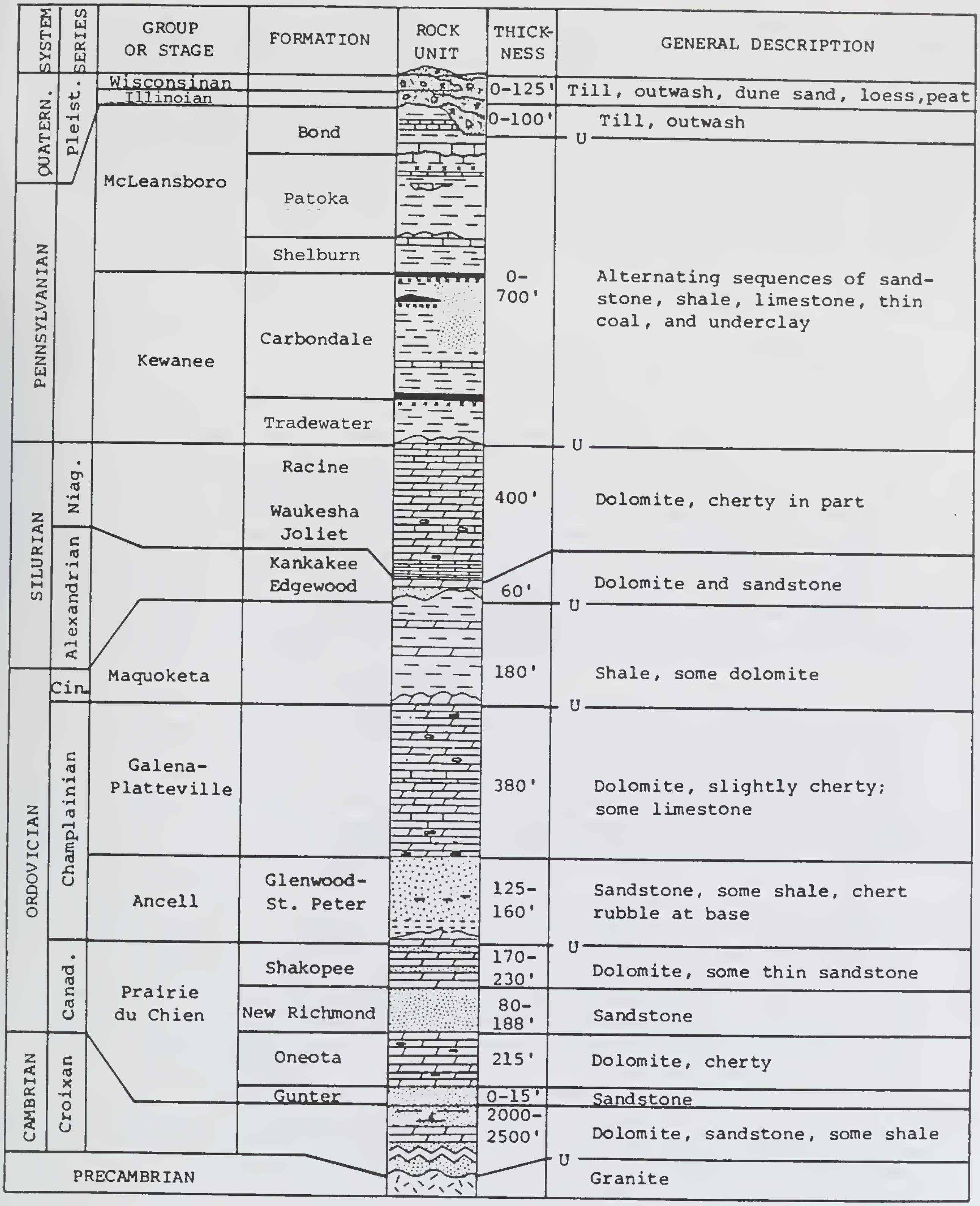


Figure 2 Generalized stratigraphic column of the field trip area.

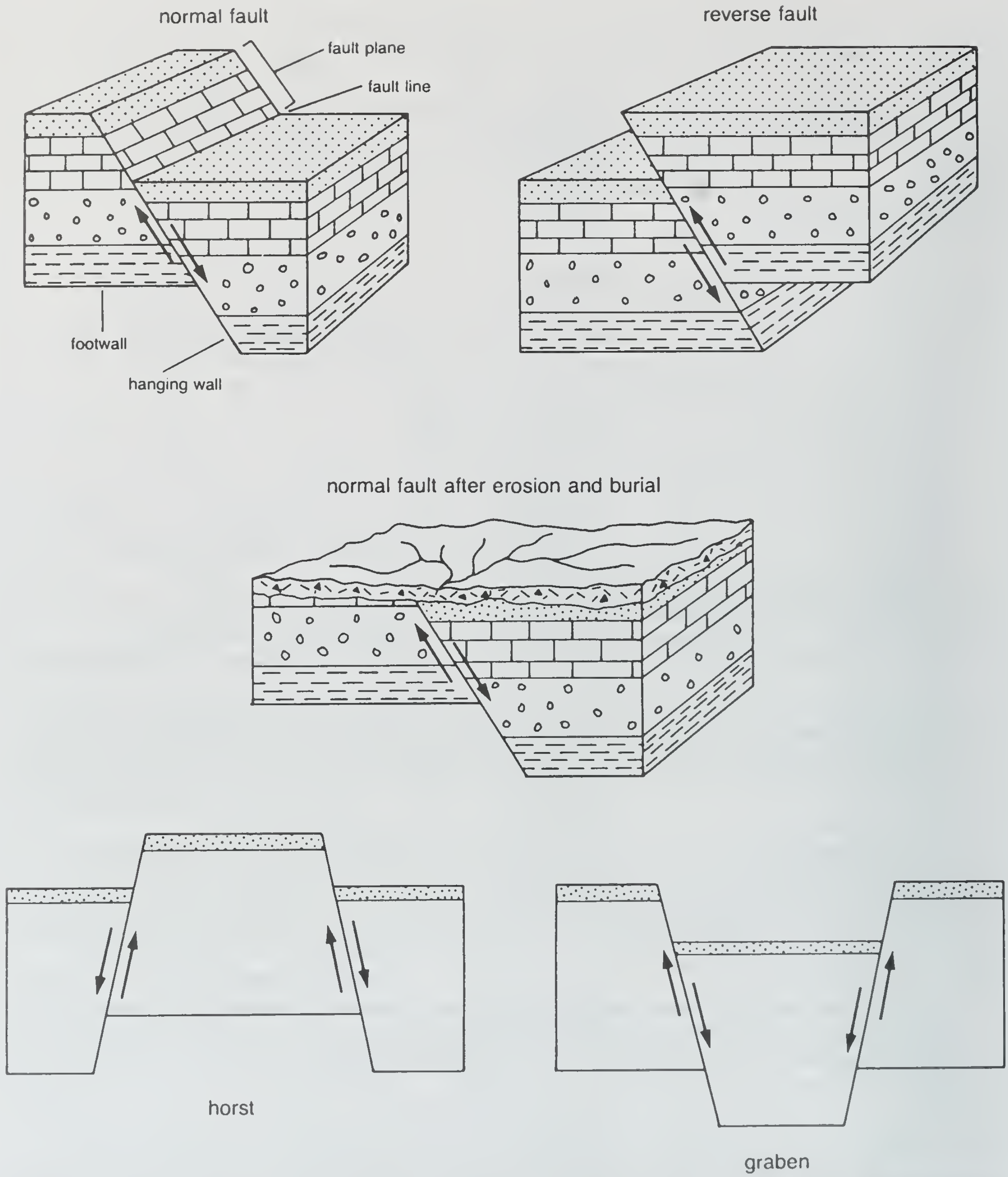


Figure 3 Diagrammatic illustrations of fault types that may be present in the field trip area (arrows indicate relative directions of movement on each side of the fault).

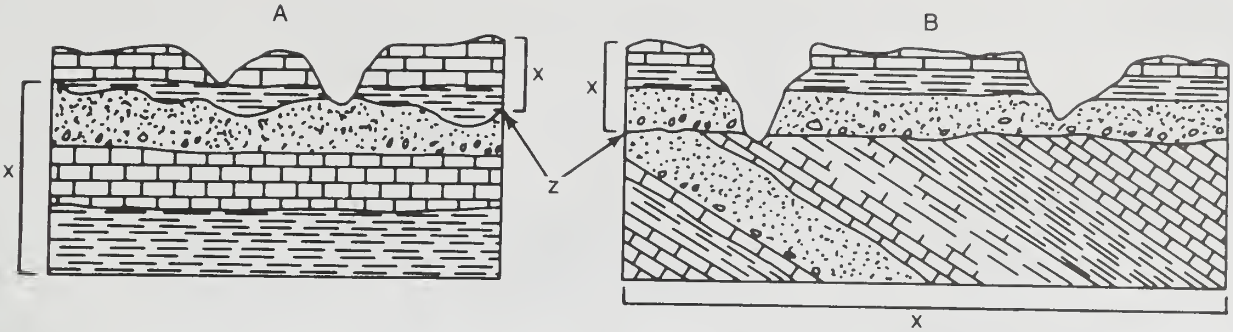


Figure 4 Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

Many of the sedimentary units, called formations, have *conformable* contacts—that is, no significant interruption in deposition occurred between formations (figs. 2 and 4). In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In some places, however, the lower formation was at least partially eroded before deposition resumed. Fossils and other evidence in the two formations indicate that there is a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4). If the *beds* above and below an unconformity are parallel, the unconformity is called a *disconformity*; if the lower beds have been tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity. Five major unconformities are shown as undulating lines across the rock columns in figure 2. Each represents an extended interval of time for which there is no rock record. Smaller unconformities also are shown in figure 2; these generally represent shorter time intervals or more localized events. At these points less material is missing from the record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinorium (figs. 1 and 5). This is a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot know just when movement along the belt ceased—perhaps it was by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

During the Mesozoic Era, which followed the Paleozoic Era, the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee formed the Illinois *Basin*, closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (figs. 1 and 5). Development of the Pascola Arch, in conjunction with the earlier sinking of deeper parts of the area to the north, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

The Pontiac-Streator field trip area straddles the La Salle Anticlinorium on the northern edge of the Illinois Basin. The La Salle Anticlinorium is more than 200 miles long and has as much as 2,500 feet of vertical relief. The anticlinorium is a complex uplift that consists of a large number of branching, sinuous monoclines, anticlines, and related domes. Within the field trip area, these structural features include the Troy Grove Dome in northwestern La Salle County, the Peru Monocline in western La Salle County, the Ancona Anticline in northwestern Livingston County, and the Pontiac Dome in central Livingston County.

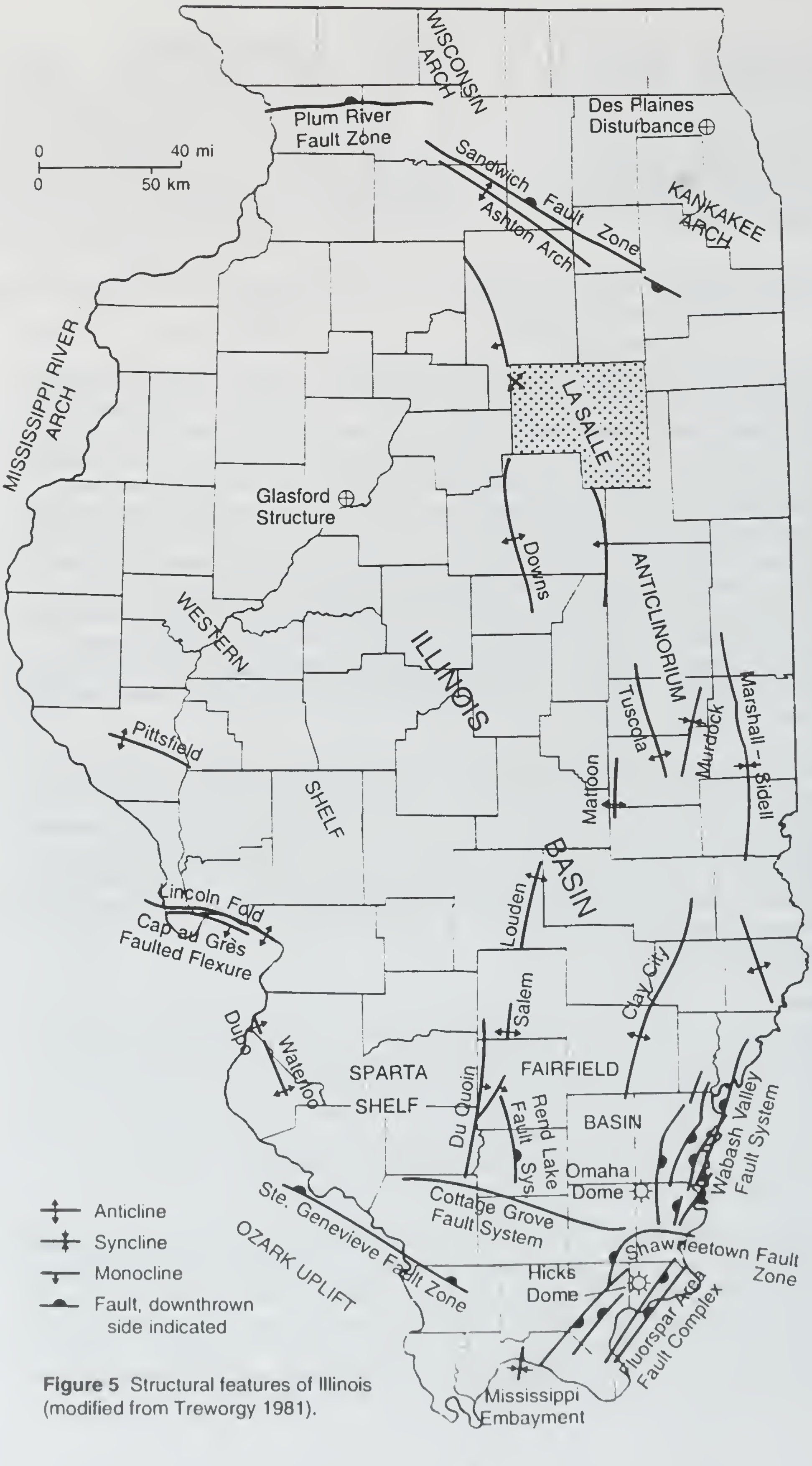


Figure 5 Structural features of Illinois (modified from Treworgy 1981).

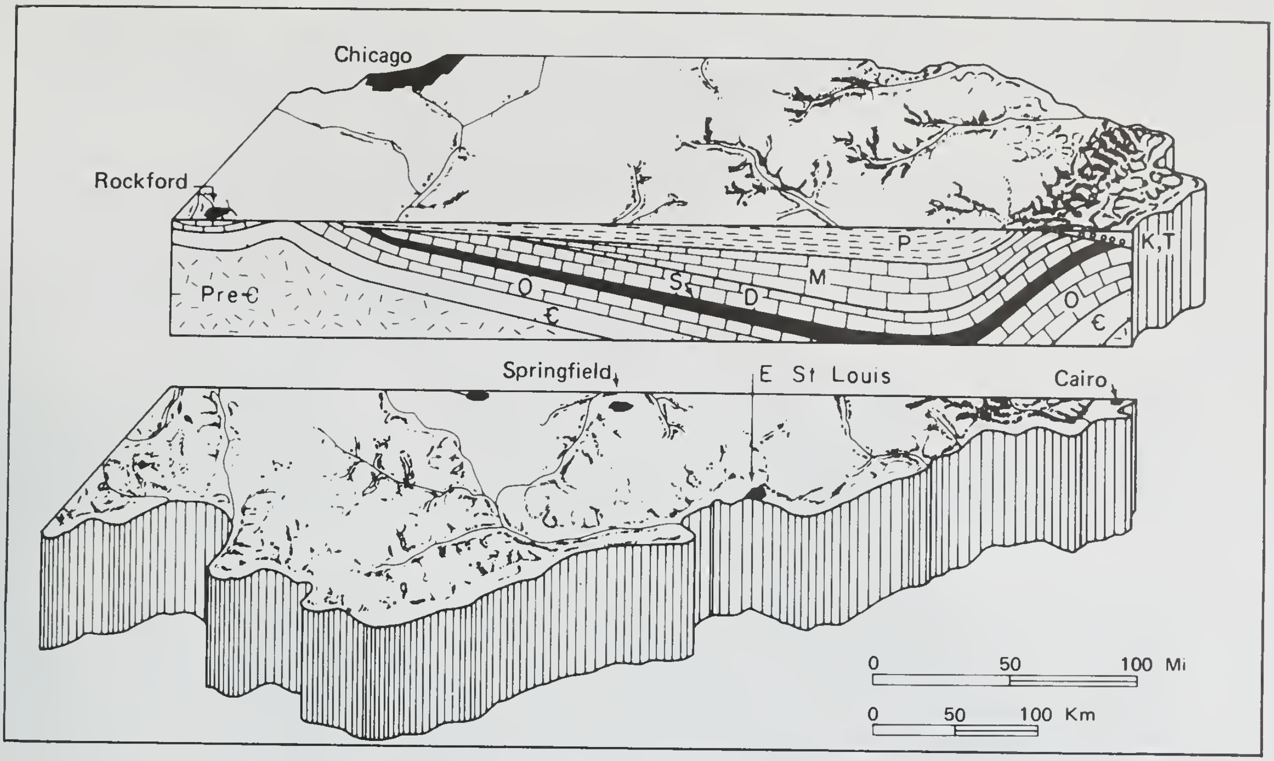


Figure 6 Stylized north–south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

Bedrock is exposed along the Vermilion River and in the limestone and shale pits within the field trip area. The highest elevations of the bedrock, 650 feet above sea level in southwest Livingston County and 600 feet in central La Salle County, occur along the crest of the La Salle Anticlinorium. Because tilting of the bedrock layers took place several times during the Paleozoic Era, the dips of successive strata vary.

Other evidence indicates that younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the La Salle and Livingston Counties area. It is possible that Mesozoic and Cenozoic (even younger) rocks could also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that latest Pennsylvanian and younger rocks perhaps as deep as 7,900 feet (about 1 1/2 miles) once covered southern Illinois. However, during the more than 240 million years since the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were erased.

During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations. Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the pre-glacial erosion surface. The erosion affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the non-lithified deposits in which our Modern Soil has developed.

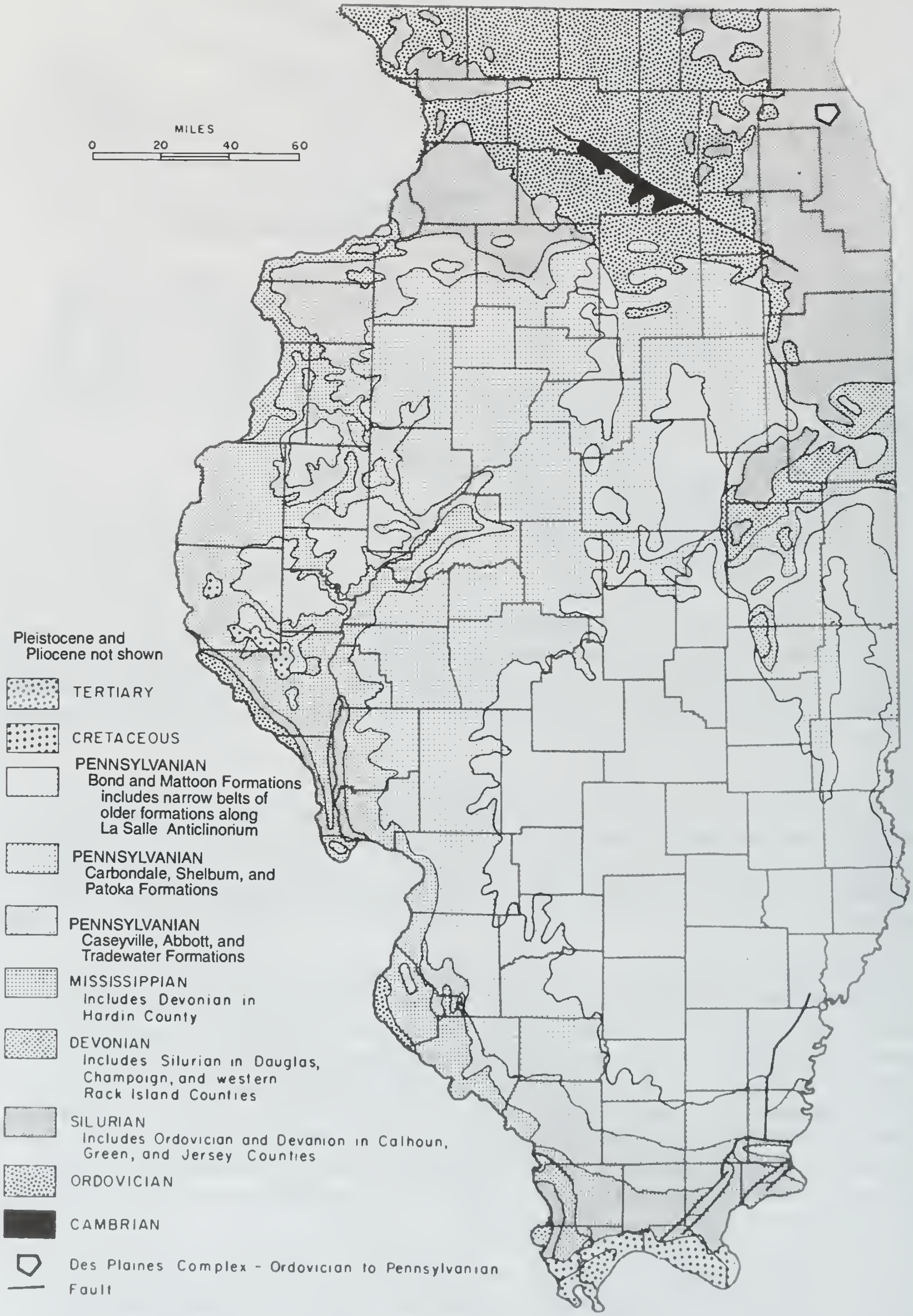


Figure 7 Bedrock geology beneath surficial deposits in Illinois.

Glacial history A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers may be found in *Pleistocene Glaciations in Illinois* at the back of the guidebook.

Erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). Prior to glaciation, La Salle County was drained by an east-west ancient bedrock valley called the Ticona Channel. After glaciation, a new drainage channel developed north of the older Ticona Channel. This new channel is called the Illinois Valley. Because of the irregular bedrock surface and erosion, glacial *drift* is unevenly distributed across La Salle and Livingston Counties.

During the Pleistocene *Epoch*, beginning about 1.6 million years ago, massive sheets of ice (called continental glaciers), thousands of feet thick, flowed slowly southward from Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). During the Illinoian glacial stage, which began around 300,000 years B.P., North American continental glaciers reached their southernmost position slightly more than 200 miles south of here (fig. 9), in the northern part of Johnson County.

Until recently, glaciologists assumed that these glaciers may have been a mile or more thick. However, the maximum thickness of the ice may have been only about 2,000 feet in the Lake Michigan Basin and about 700 feet across most of the Illinois land surface (Clark et al. 1988). That conclusion was made using several lines of research evidence: (1) the degree of consolidation and compaction of rock and soil materials that must have been under the ice, (2) comparisons between the inferred geometry and configuration of the ancient ice masses and those of present-day glaciers and ice caps, (3) comparisons between the mechanics of ice-flow in modern-day glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits, and (4) the amount of rebound of the Lake Michigan Basin as the heavy mass of glacial ice (that had depressed the land beneath it) melted and relieved the pressure.

The *topography* of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams. In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. Studies of mine shafts, water-well logs, and other drill-hole information in addition to scattered bedrock exposures in some stream valleys and roadcuts show that the present land surface of this region does not reflect the underlying bedrock surface. The preglacial bedrock surface has been significantly modified and is subdued by glacial deposits. The cities of Pontiac and Streator lie in an area surrounded by the Farm Ridge Moraine to the north, the Norway, Ransom, and Chatsworth Moraines to the east, the Strawn Moraine to the south, and the Minonk Moraine to the west. These moraines were formed during the Woodfordian *Substage*, which began about 22,000 B.P. (See *Pleistocene Glaciations in Illinois* at the back of the guidebook).

Although Illinoian glaciers probably built morainic ridges similar to those of the later Wisconsinan glaciers, Illinoian moraines apparently were not so numerous and have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. For these same reasons, Illinoian glacial features generally are not as conspicuous as the younger Wisconsinan features.

A thin cover of wind-blown silt called Richland *Loess* (pronounced "luss") mantles the glacial drift in Livingston and La Salle Counties. Within the Vermilion valley, the Richland Loess is less than 25 inches thick. It increases to a maximum of 6 feet in southwest Livingston County and is 2 to 4 feet thick in eastern Livingston County. The Richland Loess thins from 8 feet in the western half of La Salle County to 4 feet in the eastern half, and it is less than 2 feet thick within the Fox Valley drainage area. This fine-grained dust reaches thicknesses exceeding 15 feet east of the field trip area along

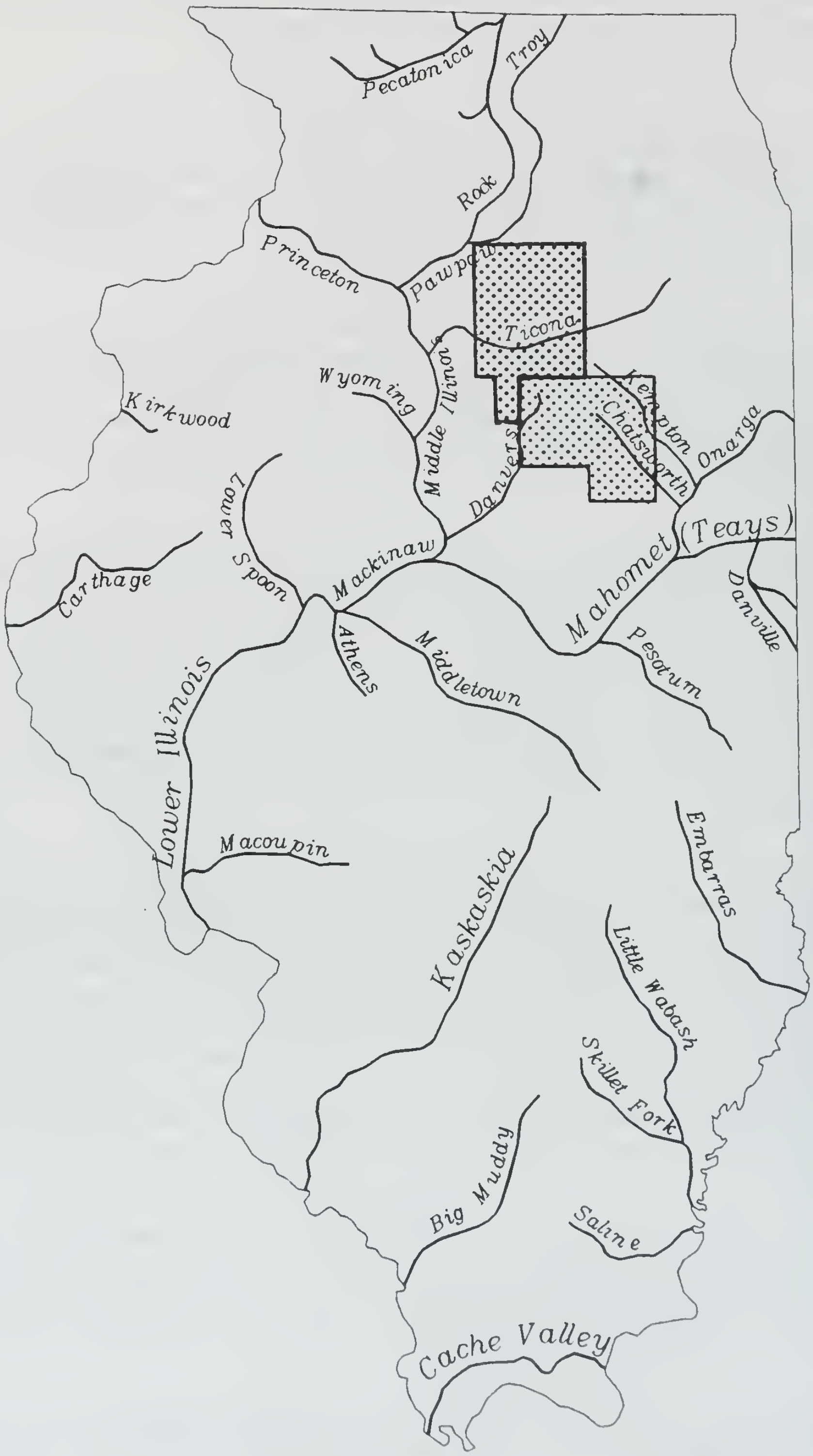


Figure 8 Bedrock valleys of Illinois, study area highlighted (modified from Bristol and Buschbach 1973).

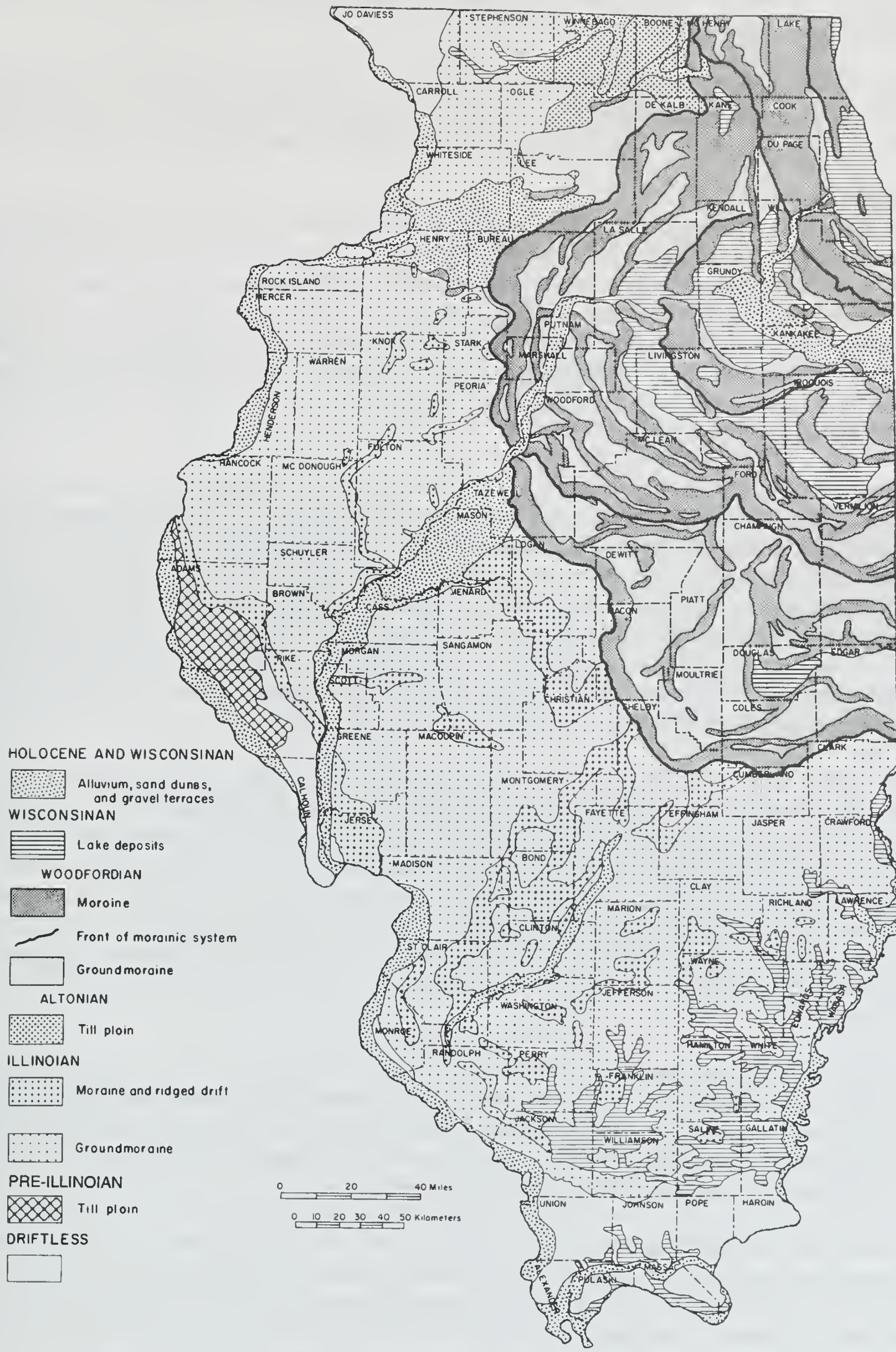


Figure 9 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

the Mississippi and Illinois Rivers. Soils in this area have developed in the loess and the underlying weathered silty, clayey Wisconsinan *till.*

Within the field trip area, glacial drift ranges in thickness from a few feet along the crest of the La Salle Anticlinorium to more than 25 feet thick in Livingston County along the Vermilion River. The drift increases in thickness to as much as 200 feet, which corresponds with the location of the moraines.

Geomorphology

Physiography The Pontiac-Streator field trip area is located within the Bloomington Ridged Plain of the *Till Plains* Section of the Central Lowland Physiographic Province (fig. 10). The Bloomington Ridged Plain is characterized by low, broad morainal ridges of Woodfordian Age separated by wide, comparatively flat areas. Although the morainal ridges are conspicuous at a distance, their gentle backslopes (and locally frontal) slopes make them less obvious close at hand. Morainal topography is well preserved and only near major streams does the morainal topography give way to *fluvial* landforms. For a more complete description of glacial landforms, see *Pleistocene Glaciations in Illinois* at the back of the guidebook.

According to Horberg (1950) and others (e.g., Leighton et al. 1948), an extensive lowland called the "central Illinois *peneplain*" had been eroded prior to glaciation into the relatively weak rocks of Pennsylvanian age east and south of the present-day Illinois River. Apparently, just before the advent of glaciation, an extensive system of *bedrock valleys* was deeply entrenched below the central lowland surface level. As glaciation began, streams probably changed from erosion to aggradation, that is, their channels began to build up and fill in because the streams did not have sufficient volumes of water to carry and move the increased volumes of sediment. To date there is no evidence indicating that the early fills in these preglacial valleys ever were completely flushed out of their channels by succeeding deglaciation meltwater torrents.

Drainage In the parts of Livingston and La Salle Counties covered by this field trip, drainage is controlled by the location of Woodfordian moraines, which form natural drainage divides. The Vermilion River is the major tributary to the Illinois River within this area. The Vermilion River drainage basin covers 1,230 square miles and is located between the Minonk Moraine to the west and the Norway, Chatsworth, and Ransom morainic complex to the east. The Vermilion River flows between the Farm Ridge Moraine and the Minonk Moraine at its northern end and eventually joins the Illinois River near the city of Lowell. Drainage east of the Ransom Moraine in northeastern Livingston County is towards the Mazon River, which empties into the Illinois River near the town of Morris in Grundy County.

The Vermilion River and its tributaries have incised through a relatively thin cover of unconsolidated materials overlying the La Salle Anticlinorium. Sedimentary rocks of Pennsylvanian Age are exposed along the waterways throughout the field trip area. The Vermilion River flows from the southeast to the northwest, past the cities of Pontiac and Streator. Most streams in the modern drainage system of this field trip area have low *gradients* (bottom slopes).

Relief The highest land surface on the field trip route is near Stop 10 along the Farm Ridge Moraine, where the surface elevation is slightly more than 680 feet above mean sea level (msl). The lowest elevation is about 490 feet msl along the Vermilion River at Stop 11. The surface relief of the field trip area, calculated as the difference between the highest and lowest surfaces, is about 190 feet. *Local relief* is most pronounced along the Vermillion River at Stop 11, where it is greater than 135 feet within a distance of approximately 1,500 feet.

Mineral Resources

Mineral production Of the 102 counties in Illinois, 98 reported *mineral* production during 1992, the last year for which complete records are available. "Complete" may be somewhat of a misnomer

Figure 10 Physiographic divisions of Illinois.

in that stone production is reported for the odd-numbered years, and sand and gravel production is reported for the even-numbered years. Furthermore, not all companies report their production figures and values to the U.S. Bureau of Mines. Estimates for the total stone production for 1992 (actually 1991 production) are included in the total value given for mineral production. The total value of all minerals extracted, processed, and manufactured in Illinois during 1992 was $2,894,300,000, 0.5% lower than the 1991 total. Minerals extracted accounted for 90% of this total. Coal continued to be the leading commodity, accounting for 64% of the total, followed by industrial and construction materials at 21.4%, and oil at 14.2%. The remaining 0.4% included metals, peat, and gemstones. Illinois ranked 13th among the 31 oil-producing states in 1992 and 16th among the 50 states in total production of nonfuel minerals but continues to lead all other states in production of fluorspar, industrial sand, and tripoli.

La Salle County ranked 8th and Livingston County ranked 45th among all Illinois counties in 1992 on the basis of the value of all minerals extracted, processed, and manufactured. Economic minerals currently mined in La Salle County include industrial sand, stone, sand and gravel, and clay. Livingston

County production includes stone, clay, and sand and gravel. Livingston County was the first and La Salle County was the second leading producers of common clay. Common clay is defined as a clay or clay-like material that is sufficiently plastic to permit ready molding. Common clays and shales mined in Illinois are used to manufacture bricks, draintiles, dinnerware, and cement. The average value per ton of common clay in Illinois in 1992 was $4.00.

Although no coal mines are currently active in either La Salle or Livingston counties, cumulative production equals 65,547,638 and 10,111,437 tons, respectively. Coal has been mined from the Colchester, Herrin, and Danville Coals.

Groundwater Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential. The availability of this mineral resource is essential for orderly economic and community development. More than 48% of the state's 11 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply. Groundwater is derived from underground formations called *aquifers*. The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

Because glacial deposits occur in this area, sand and gravel deposits are common throughout most of the county. However, most of these deposits are thin and do not yield vast amounts of water. The exception is in the vicinity of the Ticona bedrock valley, which contains thick deposits of unconsolidated materials that include thick sand and gravel zones. These sand and gravel deposits yield commercial amounts of water for industrial and municipal water supplies.

The cities of Pontiac and Streator withdraw their municipal water supplies from the Vermilion River. The Vermilion is recharged from the glacial materials and by springs within the limestones that outcrop along the river. Throughout Livingston and southern La Salle Counties, small municipal and farm water supplies are obtained from shallow Pennsylvanian formations. In the northern and northeastern part of Livingston County and in most of La Salle County, water supplies have been obtained from the Silurian dolomites and the St. Peter Sandstone (Selkregg and Kempton 1958). In eastern La Salle County, the Galena-Platteville dolomite and the Prairie du Chien dolomites have supplied domestic water (Hackett and Bergstrom 1956).

GUIDE TO THE ROUTE

Assemble in the parking lot on the west side of Pontiac High School (NW NE NW Sec. 23, T28N, R5E, 3rd P.M., Livingston County; Northeast Pontiac 7.5-Minute Quadrangle [40088H5]*). Mileage calculations will start at the intersection of Elm Street and Indiana Avenue.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by a vehicle with flashing lights and flags, then obey the signals of the Illinois State Geological Survey (ISGS) staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Note: Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips:

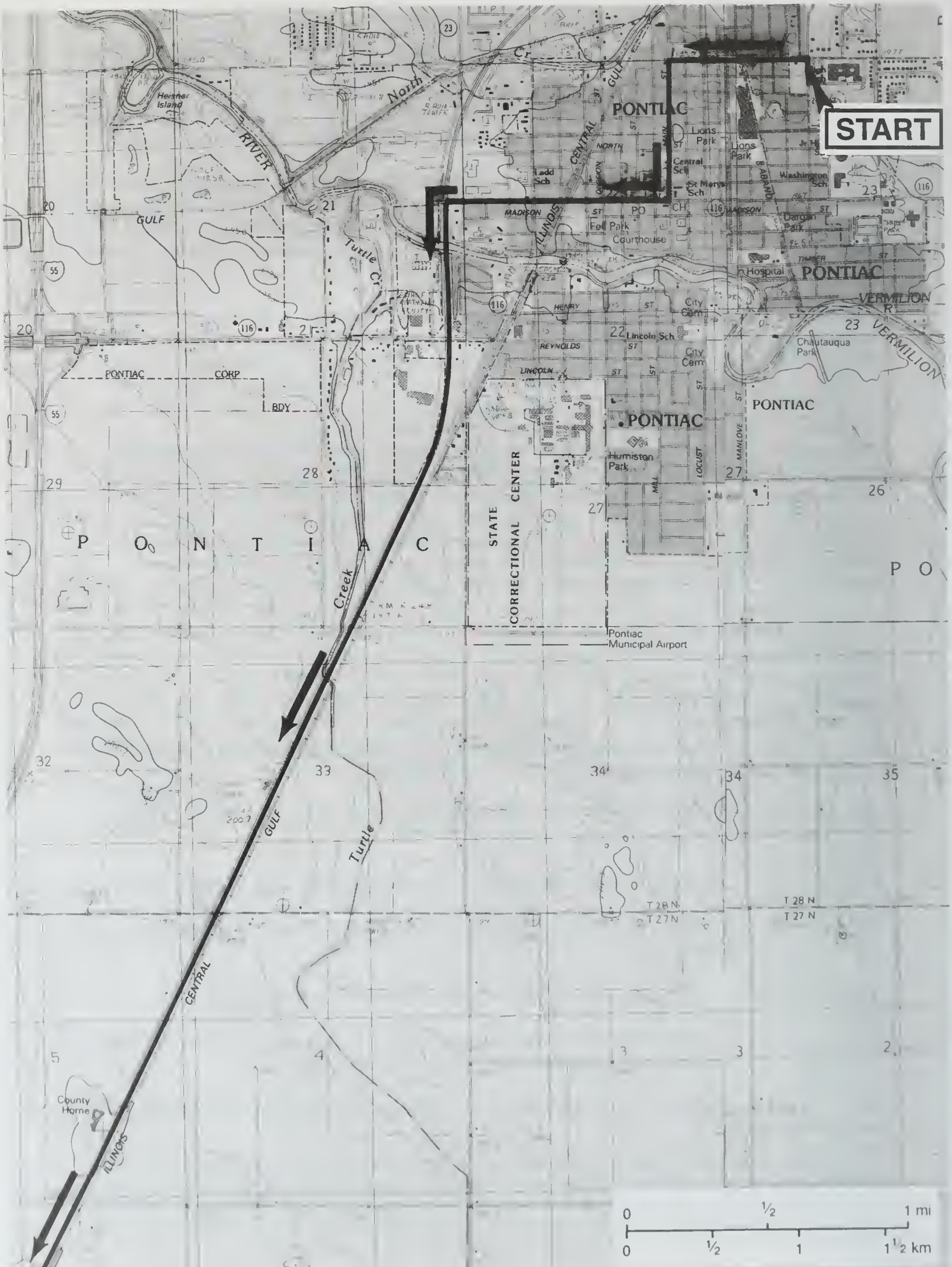
- Please do not litter or climb on fences.
- Leave all gates as you found them.
- These simple rules of courtesy also apply to public property.

If you use this booklet for a field trip with your students, youth group, or family, **you must** (because of trespass laws and liability constraints) **get permission** from property owners or their agents before entering private property.

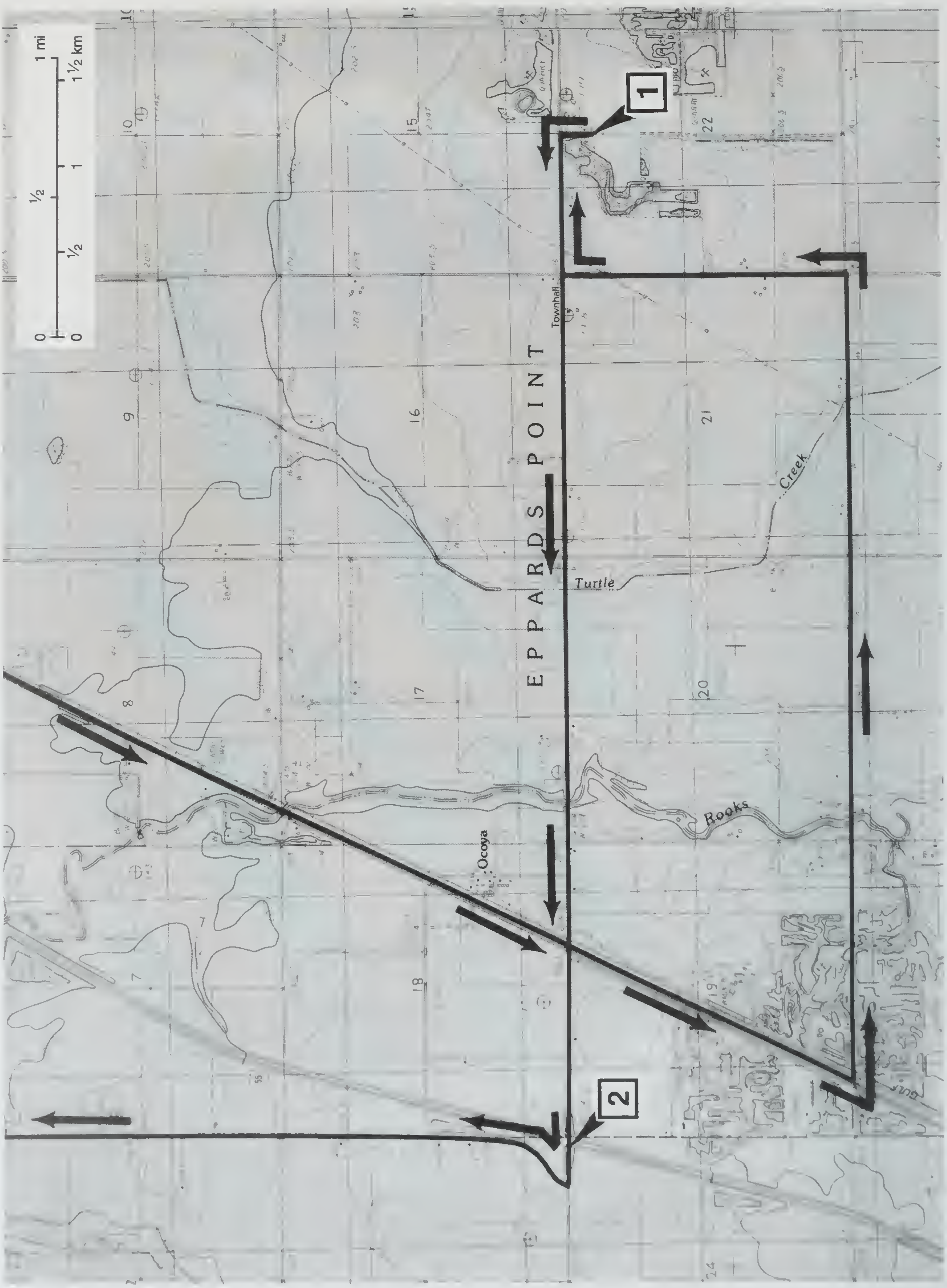
The following 7.5-minute quadrangle maps provide coverage for the area of the field trip: Flanagan North [40088H7], Leonore [41088B8], Northeast Pontiac [40088H5], Northwest Pontiac [40088H6], Southwest Pontiac [40088G6], and Streator North [41088B7].

Miles to next point	Miles from start	
0.0	0.0	Line up in the parking lot on the west side of Pontiac Township High School, exit onto Elm Street, TURN RIGHT (north).
0.0	0.0	STOP (3-way); T-intersection. TURN LEFT (west) from Elm Street onto Indiana Avenue.
0.5	0.5	STOP (1-way); T-intersection. TURN LEFT (south) on North Main Street.
0.5	1.0	CAUTION: stoplight. TURN RIGHT (west) on Howard Street (State Route [SR] 116).
0.05	1.05	CAUTION: stoplight at Mill Street. CONTINUE AHEAD (west).
0.25	1.3	CAUTION: guarded railroad crossing (two tracks). Main Line, Illinois Central Gulf (ICG) and Amtrak. CONTINUE AHEAD (west).
0.15	1.45	STOP (4-way); intersection with Ladd Street. CONTINUE AHEAD (west).

* The number in brackets [40088H5] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into 64 individual 7.5-minute quadrangles; the letter refers to the east-west row from the bottom and the last digit refers to the north-south column from the right.


START
PONTIAC
Lions Park
Central Sch
St Marys Sch
Washington Sch
Ladd Sch
Fell Park
Courthouse
Dargan Park
Hospital
VERMILION R
Chautauqua Park
City Cem
Lincoln Sch
Humiston Park
STATE CORRECTIONAL CENTER
Pontiac Municipal Airport
Heisner Island
North Cr
RIVER
Turtle Cr
Creek
Turtle
GULF
CENTRAL
ILLINOIS
PONTIAC CORP BDY
MADISON
HENRY
REYNOLDS
LINCOLN
LOCUST
MANLOVE
MILL
P O N T I A C
County Home
T 28 N
T 27 N
0 ½ 1 mi
0 ½ 1 1½ km

0.3	1.75	CAUTION: stoplight; intersection of SR 116 and 23. TURN LEFT (south) on the west side of the divided highway (SR 116, Historic US Route 66).
0.1	1.85	Cross Vermilion River. Limestone is exposed in the Vermilion River bed adjacent to the bridge. Note: the sewage treatment plant is south of the bridge on the west side of road.
0.35	2.2	CAUTION: stoplight; intersection of SR 116 and Historic US Route 66. Leave SR 116 and CONTINUE AHEAD (south) on Historic US Route 66.
0.65	2.85	Note: the route is crossing the relatively flat floor of Glacial Lake Pontiac.
0.6	3.45	Cross Turtle Creek.
0.4	3.85	Illinois State Police Headquarters District 6 on the right.
0.55	4.4	1500N intersection, CONTINUE AHEAD.
0.8	5.2	Livingston Manor Nursing Home on the right. The low rise here offers a good view of the old lake plain.
0.3	5.5	Intersection (1400N), CONTINUE AHEAD.
1.05	6.55	Cross Rooks Creek.
0.55	7.1	Intersection (1250N), CONTINUE AHEAD.
0.2	7.3	To the left is the hamlet of Ocoya.
0.3	7.6	Intersection (1200N), CONTINUE AHEAD.
0.6	8.2	To the right is the abandoned Wagner Quarry. CONTINUE AHEAD (south).
0.35	8.55	CAUTION: move to the inside lane and prepare to turn left. To the left is the abandoned Ocoya Quarry. Just before the turn on the right is another abandoned Wagner Quarry. Note: the glacial till is only 3 feet thick in this area.
0.15	8.7	CAUTION: TURN LEFT (east) onto 1100N. WARNING: you will cross the northbound two lanes.
0.05	8.75	WARNING: USE EXTREME CAUTION in crossing the Illinois Central Gulf railroad track (fast trains).
0.05	8.8	To the left is the abandoned Valley View Industries Quarry. Across the road to the right (south) is a reclaimed portion of an abandoned quarry that has been turned into some beautiful home sites.
0.4	9.2	CAUTION: narrow bridge.
0.1	9.3	To the right is a stockpile of topsoil and glacial material.
0.25	9.55	CAUTION: STOP (2-way) intersection (1300E and 1100N). CONTINUE AHEAD (east).


0 ½ 1 mi
0 ½ 1 1½ km
EPPARDS POINT
Townhall
Turtle
Creek
Rooks
Ocoya
1
2

0.05	9.6	Cross Rooks Creek.
0.05	9.65	Oak woods to the left; the lake plain is flat for a distance of nearly 2 miles here.
0.9	10.55	CAUTION: Crossroad of intersection (1100N and 1400E); 2-way stop from the left and right. CONTINUE AHEAD (east).
0.55	11.1	Cross Turtle Creek.
0.45	11.55	STOP (2-way); TURN LEFT (north) at the intersection of 1100N and 1500E.
1.0	12.55	STOP (2-way); TURN RIGHT (east) at the intersection of 1200N and 1500E.
0.5	13.05	TURN RIGHT (south) at the west entrance gate to the Weston Quarry Plant area. You MUST have permission to enter this property.

STOP 1 We'll see an exposure of the La Salle Limestone Member and quarrying operations at Vulcan Materials Corporation, Weston Quarry (NE NE NE NW, Sec. 22, T27N, R5E, 3rd P.M., Livingston County, Southwest Pontiac 7.5-Minute Quadrangle [40088G6]).

Most of the limestone quarried in the Pontiac area is correlated with the La Salle Limestone Member of the Bond Formation (figs. 11, 12, and 13), which outcrops along the Illinois River, near the city of La Salle. Although the limestones are correlated, they cannot be physically traced from the Pontiac area to the La Salle area. Physical correlation is hampered where the La Salle limestone has been removed by erosion and where the elevation of the beds varies because of structural influences.

Limestones in the Pontiac area show variation in thickness, lithology, and structural attitude. The La Salle Limestone, as indicated by drilling and outcrop data, consists of several relatively thin limestone units intermittently separated by thin shale or mudstone units. These limestone units consist of one or more beds, and they may be as thin as a few inches or as thick as several feet. All of the limestone units become thinner away from the Pontiac area. Some of the limestone consists of intraformational breccias—limestone that has been broken in place and then cemented back together. This form of limestone contains a few well preserved fossils. There are also thin, micritic (fine grained) and argillaceous (clayey) limestone layers that contain well preserved fossils, some of which are preserved as internal molds (impressions that show the internal form of a fossil).

One of the better places to look for loose or easily collectable fossils is in and along the thin shale or mudstone partings or beds that separate the limestone intervals. Fossil collecting at Weston is sparse. You would have better luck collecting fossils in the Highway 23 pit north of Pontiac. At the Highway 23 pit, you can find loose brachiopods and internal brachiopod molds as well as crinoid stems. Some brachiopod internal molds are lined with very small calcite crystals. During the 1960s and early 1970s, museum quality crinoids were systematically recovered from the Wagner Stone Quarry at Ocoya by Harell Strimple of the University of Iowa. Unfortunately, this quarry was closed and abandoned in the mid-1970s and is now flooded.

Measurements of the strike (direction) and dip (angle) of the limestone intervals indicate that there are several low, very broad folds in the area. The vertical difference between fold crests and troughs is on the order of 5 to 20 feet, and the distance between fold crests is on the order of a 1/4 to 1/2 mile. The folds generally trend north-northwest to south-southeast.

The following description was made from an active face in the southern part of the quarry (fig. 12). The total thickness of the limestone exposed here is approximately 20 feet. The upper 8 feet consists

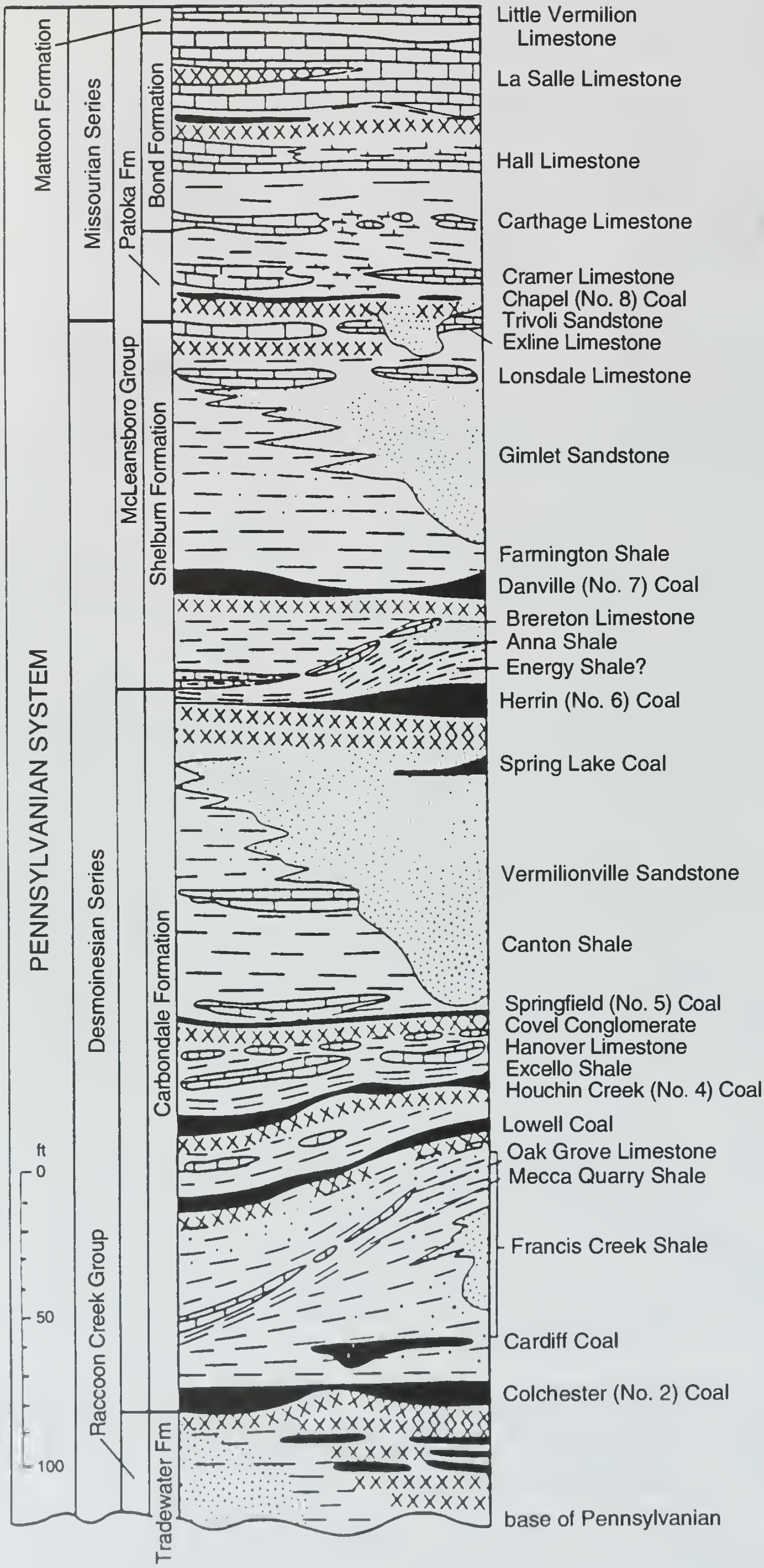


Figure 11 Generalized stratigraphic column of Pennsylvanian rocks in La Salle and Livingston Counties.

Figure 12 Highwall at Weston Quarry, showing the exposure of La Salle Limestone.

of thin to medium bedded argillaceous limestone interbedded with greenish gray shale beds. The lower 12 feet is thick to medium bedded algal-dominated limestone with thin greenish gray shale layers separating the individual beds. Small cavities filled with calcite and pyrite crystals are scattered throughout the lower 12 feet. Several zones of intraformational breccia were observed in the quarry face. The lower limestone is underlain by a thinly laminated black shale.

The environment of deposition of the La Salle Limestone is directly related to the La Salle Anticlinorium (figs. 1 and 5), which was high enough to cause a rapid *shoaling* of the shallow Pennsylvanian sea that repeatedly covered the area during the Paleozoic. The closely spaced changes (called facies changes) in the character of the limestone, both vertical and lateral, were caused by the constant interplay of changes in eustatic (worldwide) sea level and the relief of the La Salle Anticlinorium.

Prior to design work for street improvements in the early 1980s, engineering borings were used to determine the depth to the bedrock along some major streets in Pontiac. Most of the borings stopped at a shallow depth when rock, which was interpreted to be the top of the limestone, was encountered. It was learned upon excavation for the street improvements that the rock was really a zone of locally derived cobbles and boulders in the glacial till. Such a till is described as a bedrock till. In the late 1980s, a second set of engineering borings was completed for more street improvements. This time, however, all of the borings were advanced to the design depth of 12 feet by drilling through the limestone cobbles and boulders in the till.

0.0	13.05	Leave Stop 1. Retrace route to the west entrance gate and resume mileage count from there. STOP (1-way); west entrance gate. TURN LEFT (west) onto 1200N.

Figure 13 View of the top of a bench of La Salle Limestone in the Weston Quarry and a drilling rig.

0.5	13.55	CAUTION: Crossroad intersection of 1200N and 1500E. 2-way stop from the left and right. CONTINUE AHEAD.
1.0	14.55	CAUTION: Crossroad intersection of 1400E and 1200N. CONTINUE AHEAD (east).
0.1	14.65	Cross Turtle Creek.
0.75	15.4	Cross Rooks Creek.
0.15	15.55	CAUTION: T-intersection from the left (1300E). CONTINUE AHEAD (east) on 1200N.
0.1	15.65	CAUTION: T-intersection from the right (1290E). CONTINUE AHEAD (east) on 1200N.
0.25	15.9	CAUTION: cross guarded ICG railroad crossing. CONTINUE AHEAD (west).
0.05	15.95	STOP (2-way); crossroad intersection (Historic US 66, 1250E and 1200N). CONTINUE AHEAD (west).
0.65	16.6	Pull over and park vehicles on the right edge of the road. Note: stop on the east side of the overpass.

STOP 2 We'll discuss Lake Pontiac from the center of the Interstate 55 overpass (NE NE NE NE, Sec. 24, T27N, R4E, 3rd P.M., Livingston County, Southwest Pontiac 7.5-Minute Quadrangle [40088G6]).

Look to the north, south, east, and west—what topographic feature stands out? If you answered "what" topographic feature, you would be right. The natural landscape at this point is practically featureless except for the spoil piles from the abandoned quarrying operations to the east. This flat plain is an ancient lake bed, a remnant of the glacial lake that once covered this area.

At least two lakes existed in the Pontiac region during Wisconsinan time (fig. 14). The earlier one, called Glacial Lake Ancona, developed during the retreat of the glacier from the Minonk Moraine. We will discuss Glacial Lake Ancona in more detail at Stop 4.

The Glacial Lake Pontiac plain is a large lenticular (lens-shaped) basin confined by the Farm Ridge Moraine 27 miles to the north, the Marseilles Morainic System (the Ransom, Norway, and northern segment of the Chatsworth Moraines) 8 miles to the east, the Minonk Moraine 4 miles to the west, and the Strawn Moraine 4.5 miles to the southeast (see fig. 14). At its broadest part, the basin is at least 12 miles wide.

The position of the Wisconsinan glacier fluctuated as it melted back. Readvances interrupted its gradual retreat into the Lake Michigan basin. In the vicinity of Chicago, it formed the Valparaiso Morainic System. Glacial Lake Chicago formed between the Valparaiso Morainic System and the ice of the Lake Michigan lobe. Lake Chicago was the ancestor of the present Lake Michigan. The Valparaiso Glacier melted rapidly, and the Illinois Valley could not always contain the tremendous volume of water flowing into it from the outlet river that had breached the Valparaiso Morainic System. Great torrents of meltwater, called the Kankakee Torrent, discharged down the Kankakee and Illinois Rivers. The Kankakee and Illinois Valleys were not large enough to handle the floods that backed up over much of the surrounding country. At its maximum extent, some of the floodwater flowed south to about 660 feet above sea level, reviving former Lake Watseka. The revived Lake Watseka, in turn, overflowed westward into the north fork of the Vermilion River. This overflow, combined with backwater from the flood in the Illinois Valley, formed Glacial Lake Pontiac. The position of the ancient lake is recognized by the 650-foot contour. The lake is responsible for the black, slightly mucky soil of the flats.

0.0	16.6	Leave Stop 2. CONTINUE AHEAD (west); cross over the I-55 overpass and prepare to turn right.
0.15	16.75	TURN RIGHT (north) onto 1180E.
0.35	17.1	Material from the borrow pit on the right was used to construct the overpass at Stop 2. Note the glacial erratics along the shoreline of the borrow pit. CONTINUE AHEAD (north).
0.65	17.75	T-intersection from the left (1300N). CONTINUE AHEAD (north).
1.0	18.75	STOP (2-way); crossroad intersection (1400N and 1200E). CONTINUE AHEAD (north).
1.0	19.75	CAUTION: unguarded crossroad intersection (1500N and 1200E). CONTINUE AHEAD (north).
1.0	20.75	STOP (1-way); T-intersection. TURN LEFT (west) onto 1600N and prepare to turn right.

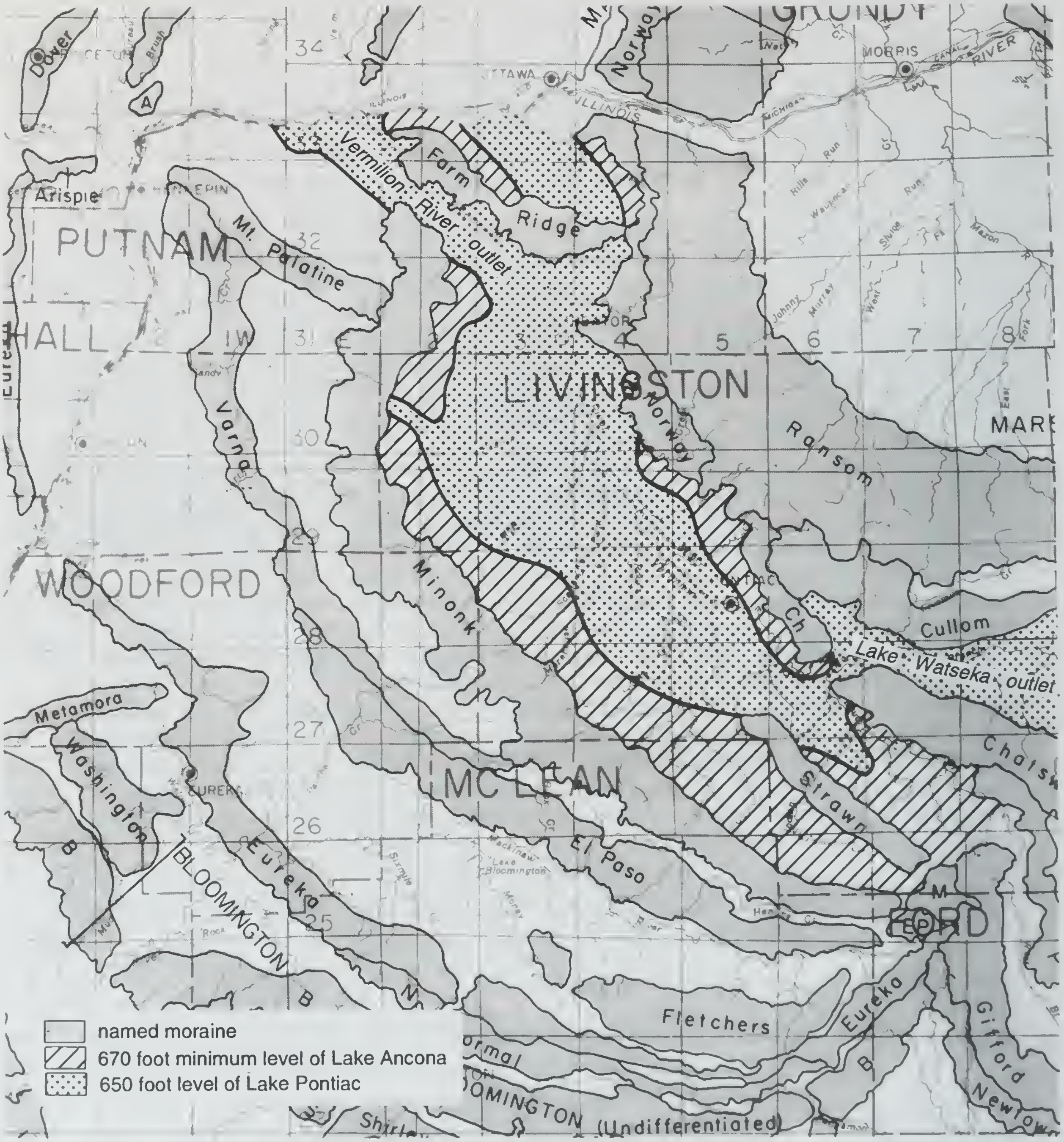
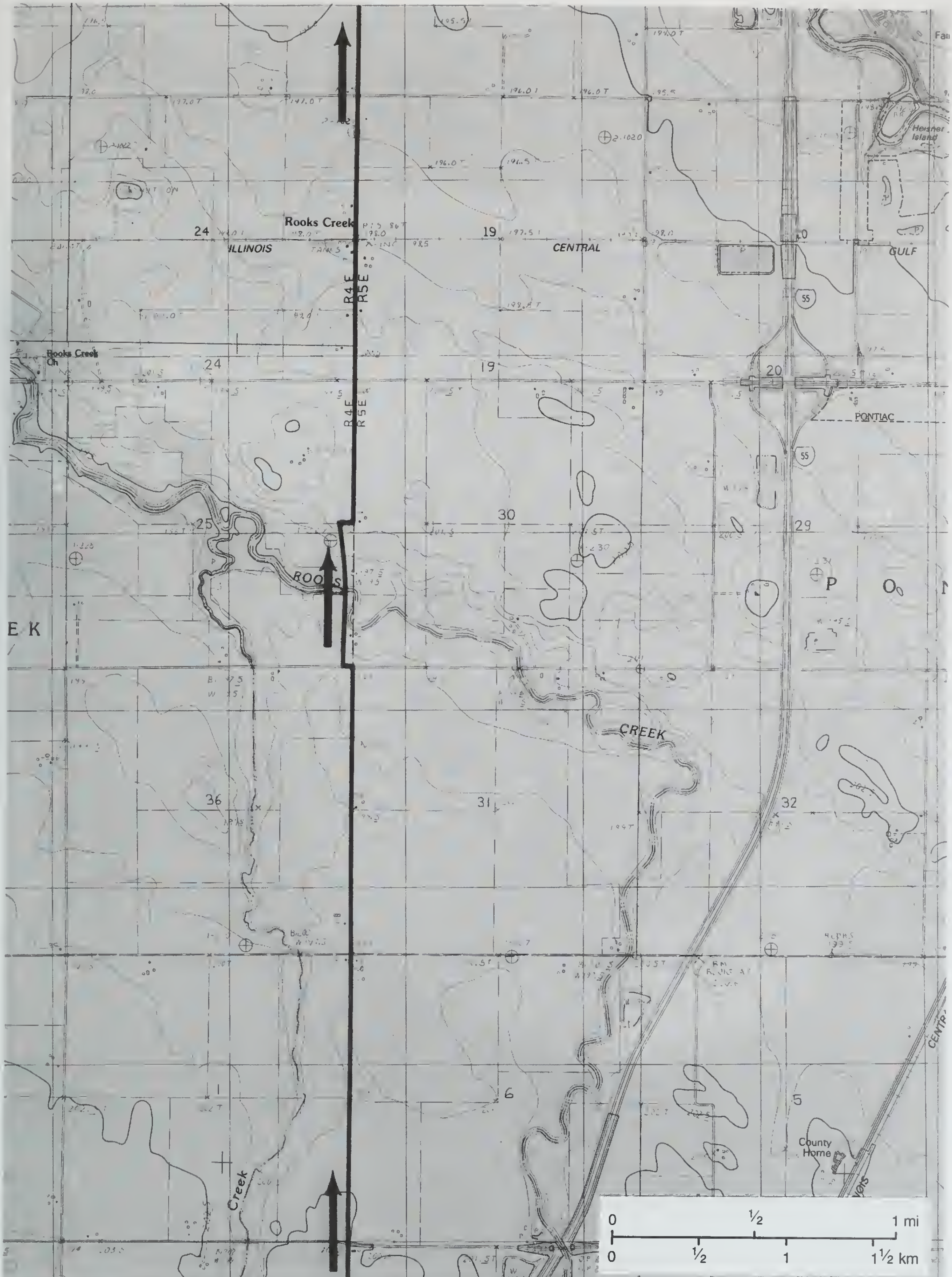
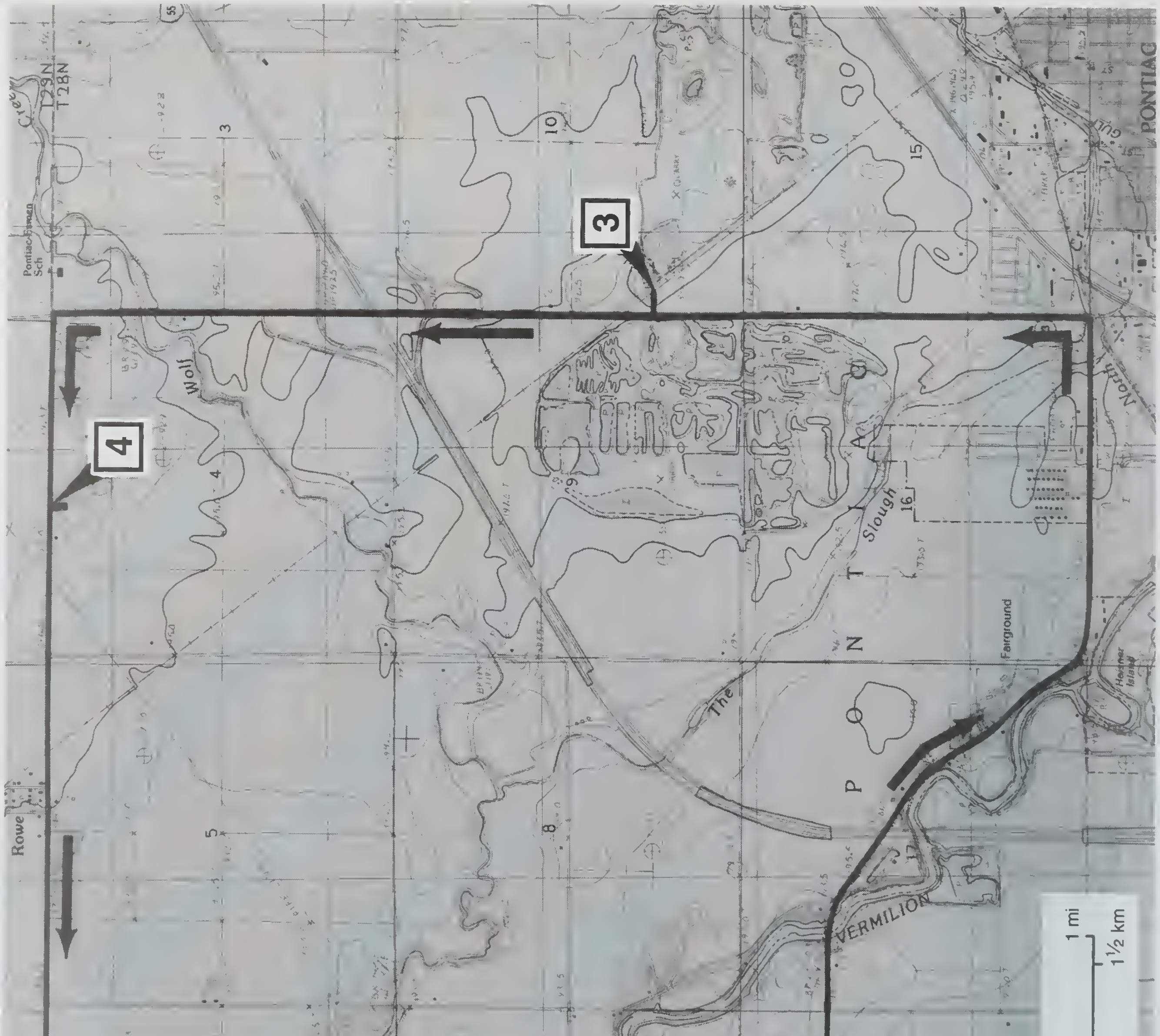


Figure 14 Distribution of Woodfordian moraines and glacial lakes in field trip area.

0.05	20.8	TURN RIGHT (north) onto 1200E.
0.2	21.0	Note the meanders in Rook Creek to the right.
0.05	21.05	Cross Rooks Creek.


Rooks Creek
24
ILLINOIS
19
CENTRAL
GULF
R4E
R5E
Rooks Creek Ch
24
19
20
PONTIAC
55
55
30
29
25
ROOKS
P O N
E K
CREEK
36
31
32
6
5
Creek
County Home
Heisner Island
0
½
1 mi
0
½
1
1½ km



T29N
T28N
Pontiac-Sch
3
4
Wolf
Creek
Rowe
Rowe Cem
McMillan Cem
The
Slough
P O N T I A C
Fairground
VERMILION
North
PONTIAC
0
½
1
1 mi
1½ km

0.8	21.85	STOP (2-way); crossroad intersection (1700N, SR 116 and 1200E). USE CAUTION in crossing SR 116. CONTINUE AHEAD (north) on 1200E.
1.0	22.85	CAUTION: Crossroad intersection of 1800N and 1200E, 2-way stop from the left and right. CONTINUE AHEAD.
0.75	23.6	STOP (2-Way), T-intersection from right. TURN RIGHT (east) onto 1875N.
0.75	24.35	T-intersection from the left (1275E). CONTINUE AHEAD.
0.25	24.6	T-intersection from the right (1300E). CONTINUE AHEAD.
0.2	24.8	Cross the Vermilion River. Limestone and underlying gray-green shale is exposed on the east and south side of the bridge along the river.
0.1	24.9	T-intersection from the left (1330E); CONTINUE AHEAD. Road curves to the right.
0.25	25.15	I-55 overpass.
0.35	25.5	Livingston County 4-H Fairgrounds are to the left; Vermilion River is to the right.
0.7	26.2	Caterpillar Plant is on the right.
0.7	26.9	STOP (1-way); T-intersection (1800N and 1500E). CAUTION: TURN LEFT (north) onto SR 23.
0.3	27.2	Crossroad intersection (1830N); CONTINUE AHEAD.
0.95	28.15	TURN RIGHT (east) into Vulcan Materials Company, Route 23 Quarry. You MUST have permission to enter this property.

STOP 3 We'll view and discuss the La Salle Limestone Member and overlying Yorkville Till Member at the Vulcan Materials, Route 23 Quarry (SW SW NW SW, Sec. 10, T28N, R5E, 3rd P.M., Livingston County, Northwest Pontiac 7.5-Minute Quadrangle [40088H6]).

Several abandoned quarries that are now filled with water cover this area. The first quarry to operate in the area was the now abandoned Pontiac Stone Company, Pontiac Quarry (SE 1/4 of Section 9), later operated by Vulcan Materials. Valley View Industries operated a second Pontiac Quarry in the NE 1/4 of Section 16. Both of these quarries are located on the west side of Route 23. The individual quarry pits are generally separated by a narrow wall of limestone (see route map).

The abandoned pit directly to the north is full of water. Mine operators in this area must deal with the possibility of water infiltrating into the quarry. The groundwater level here is very shallow and the limestone contains a significant amount of jointing, which provides an efficient flow path for the groundwater. The Route 23 Quarry (fig. 15) is relatively dry, as compared with other quarries in the area, and it generally only operates a water pump during the day. Once the pits are abandoned, they fill with water very quickly. During the preparation of this field trip, we visited the Vulcan Materials, Raube Quarry directly east of the Route 23 Quarry. This quarry was abandoned on July 29, 1995, and it was completely filled with water by August 16, 1995.

Figure 15 Photo of sidewall at Vulcan Materials, Route 23 Quarry (from the north end of the quarry), showing the nature of the La Salle Limestone.

As we mentioned at Stop 1, the La Salle Limestone in this quarry is very fossiliferous. Fossils include brachiopods, crinoids, and rugose corals. The La Salle Limestone was deposited in one of the shallow seas that repeatedly covered the area some 280 million years ago.

The following description was made at the north quarry wall (fig. 15) near the entrance from Route 23. The total thickness of the limestone exposed here is approximately 13.5 feet, in three distinct units. The upper 8 feet consist of thin bedded, *flaggy*, argillaceous, and fossiliferous limestone. The upper bed is jointed and iron stained. Scattered throughout, it has zones of intraformational breccia and zones of vugs (cavities) filled with calcite crystals. The middle unit consists of 4.5 feet of massive brecciated limestone. The lower unit consists of thin to medium bedded, greenish, argillaceous, very fossiliferous limestone. Only 1 foot of the lower unit is exposed.

0.0	28.15	Leave Stop 3. Return to the entrance gate and resume mileage. CAUTION: TURN RIGHT (north) on SR 23.
0.45	28.6	T-intersection from the right (frontage road 1975N). CONTINUE AHEAD.
0.35	28.95	Cross I-55 overpass. The low hills to the right in the distance are part of the Chatsworth Moraine, which formed part of the eastern shore of Glacial Lake Pontiac. The large hill northwest of the overpass is the Pontiac landfill.
0.3	29.25	T-intersection from the left (frontage road 2040N). CONTINUE AHEAD.

0.35	29.6	Cross Wolf Creek and prepare to turn left.
0.25	29.85	CAUTION: Crossroad intersection (SR 23 and 2100N, Rowe Road). TURN LEFT (west) onto 2100N. Note the till exposed in the ditch alongside the road just after the turn to the west.
0.15	30.0	Note: ARCO petroleum tank farm to the right.
0.5	30.5	TURN LEFT at the entrance to Envirite Corporation Landfill.

STOP 4 We'll get an overview of the landfill operation and see an exposure of glacial materials in a borrow pit at the Envirite Corporation Landfill (NE NE NE NW, Sec. 4, T28N, R5E, 3rd P.M., Livingston County, Northwest Pontiac 7.5-Minute Quadrangle [40088H6]).

From what we have observed so far today, this would seem to be an unlikely site for a sanitary landfill (fig. 16) because the glacial sediments are fairly thin and they overlie a jointed limestone. Pleistocene surficial materials in this locality, however, average about 45 feet thick. The till is relatively tight and impervious, and it provides a good seal to contain the waste materials.

This site is located on ground moraine in front of the Marseilles Morainic System, which lies to the northeast. From 35 to 56 feet of glacial sediments overlie bedrock in this area. The thinnest glacial cover overlies the highest areas on the bedrock surface. The thickest glacial sediments are in the center and east-center parts of the site. The underlying bedrock consists of Pennsylvanian La Salle Limestone.

The glacial sequence from bedrock to the ground surface consists of gray silty Malden till, silty clay and clayey silt lake deposits, and gray very clayey Yorkville till. The Malden till is 4 to 24 feet thick, averages about 15 feet thick, and contains some discontinuous sand lenses. The lake deposits consist of interfingering silt, silty clay, silty sand, and sand. They range from about 6 to 27 feet thick and average about 10 to 15 feet thick. The Yorkville till ranges from about 6 feet thick in the north to more than 20 feet in the center of the site.

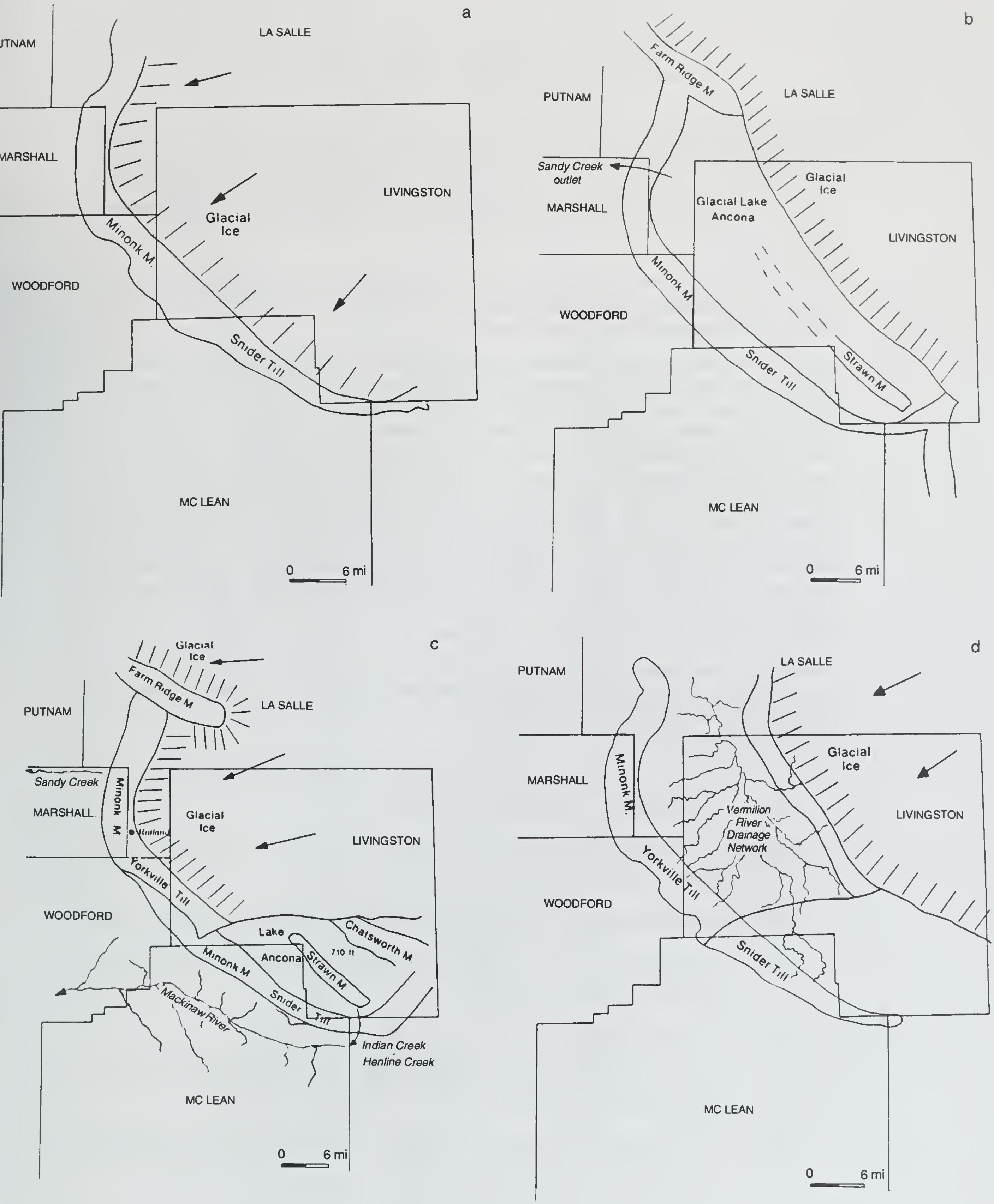
The exposure that we will examine changes from day to day as material is "borrowed" for use as earthen liner for the cells within the landfill. The exposure we studied in preparation for this trip consisted of about 11.5 feet of weathered light brown Yorkville till overlying 1 to 2 feet of gray till unaltered by weathering. The heavy dense clayey aspect of the lower part of the Yorkville probably represents locally entrained lake deposits. Below the Yorkville was about 5.5 feet of lake sediments consisting of gray, dense lake clay interbedded with light tan to yellow cross-bedded sand. Below the lowest finger of lake clay was a cross-bedded gray sand (fig. 17).

As the Malden ice (fig. 18A) melted back from this locality, meltwater became trapped between the Minonk Moraine to the southwest and the retreating ice front, forming Glacial Lake Ancona (fig. 18B). Yorkville ice then advanced again across the northern part of the lake, forming the Farm Ridge Moraine (fig. 18C). When the Yorkville ice retreated to the position of the Marseilles Morainic System, the Vermilion River drainage network developed as an outlet for Glacial Lake Ancona, draining the lake northward between the Minonk and the Farm Ridge Moraines (fig. 18D). Wolf Creek, south of the landfill site, is a tributary to the Vermilion River.

We can stand here, at an elevation of nearly 650 feet above mean sea level, and imagine the ice front on the horizon, about 5 or 6 miles to the northeast, as it formed the Marseilles Morainic System. Today the crest of the Marseilles stands at about 760 to 770 feet above sea level, more than 100 feet higher than we are here. Within a few miles to the south of this locality are lake sediments of Glacial Lake Pontiac, formed as another ice marginal lake during retreat of the Yorkville ice front (see Stop 2).

Figure 16 Landfill operation at the Envirite Corporation Landfill.

Figure 17 Sand lens with cross bedding in Lake Ancona sediments.



ure 18 Evolution of Lake Ancona.

Livingston Landfill
Ted Neura and Donna Kipfer, County Environmental
Subsidiary of Envirite Corporation

The Livingston Landfill has been operating since approximately 1980. Currently, the facility accepts about 2,000 tons per day of solid waste. The solid waste consists primarily of municipal solid waste (MSW) and non-hazardous special waste. The waste is received from the northeast quadrant of the state of Illinois. In 1987, the facility revised its engineered design to exceed, at that time, state standards for a non-hazardous special waste and MSW landfill.

There are many significant factors involved in developing a solid waste disposal facility (landfill). Such factors include combining the appropriate geologic and hydrogeologic setting with a compatible engineered design.

The current facility design is a double composite landfill liner system that utilizes state-of-the-art technologies. The components of the system, from top to bottom, (figs. 19 and 20) include a primary leachate collection system, which consists of a minimum of 12 inch layer of granular drainage material, or its equivalent, to collect leachate (liquid that percolates through waste materials) which would otherwise accumulate at the liner surface. The accumulated leachate will be conveyed via a pump station to a holding tank that will store the leachate until off-site treatment can be provided. Beneath the primary leachate collection system is a geotextile, which is utilized as a cushion or filter, a primary 60 mil HDPE geomembrane liner, a primary 3 foot minimum recompacted clayey liner, a secondary leachate collection system, which consists of a geotextile and a geonet, and a secondary recompacted clayey liner. Both the primary and secondary clayey liners are composed primarily of the Yorkville and Malden Tills, which are available on-site, and must meet a permeability requirement of 1×10^{-7} cm/sec.

In addition to the double composite liner and leachate collection system, a comprehensive quality program is implemented to ensure construction is in accordance with the design. Furthermore, there will be a landfill gas monitoring program and a minimum of 30 years of postclosure care provided.

0.0	30.5	Leave Stop 4, TURN LEFT onto 2100N.
0.45	30.95	Crossroad intersection (1400E and 2100N), 2-way stop from the left and right. CONTINUE AHEAD.
0.3	31.25	Abandoned railroad right-of-way. Enter Rowe. CONTINUE AHEAD (west).
0.7	31.95	Crossroad intersection (1300E and 2100N), 2-way stop from the left and right. CONTINUE AHEAD.
0.9	32.85	Cross Wolf Creek.
0.05	32.9	Crossroad intersection (1200E and 2100N), 2-way stop from the left and right. CONTINUE AHEAD.
0.3	33.2	Entrance to the small abandoned quarry on the left. CONTINUE AHEAD (west).
0.5	33.7	TURN RIGHT at the entrance to Humiston Woods Nature Center.

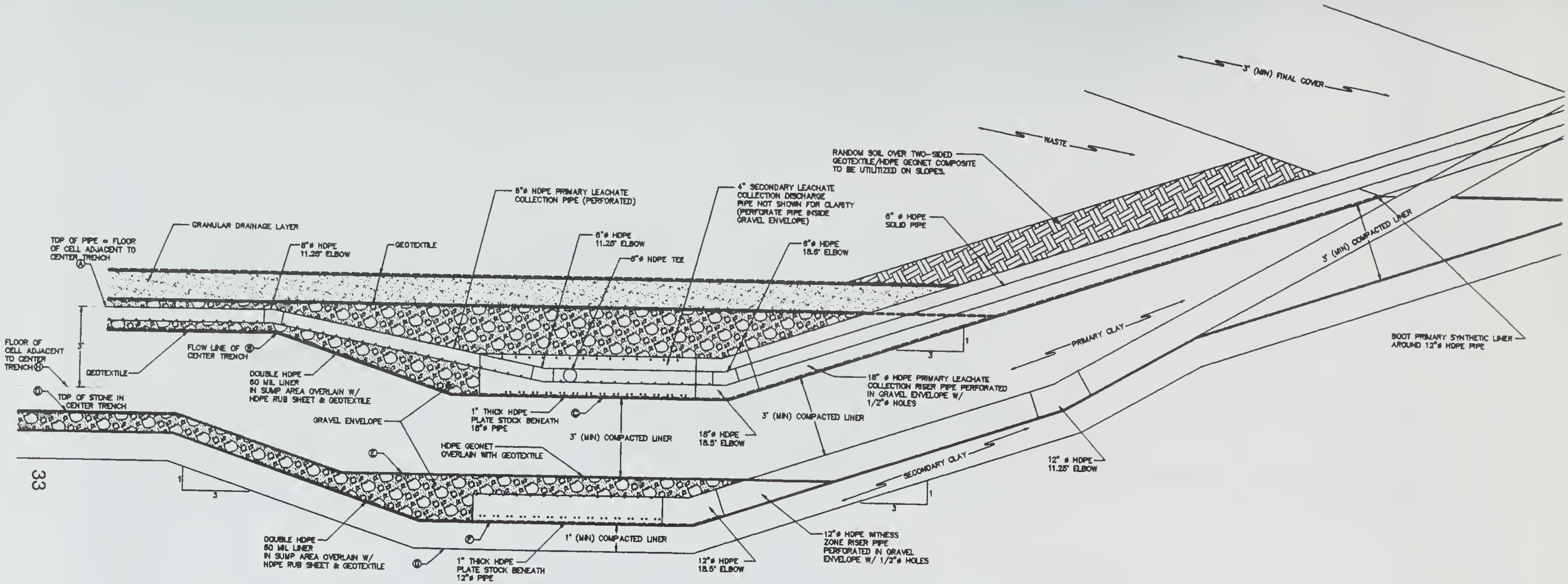


Figure 19 Primary and secondary slope riser details (courtesy of County Environmnetal, Livingston Landfill).

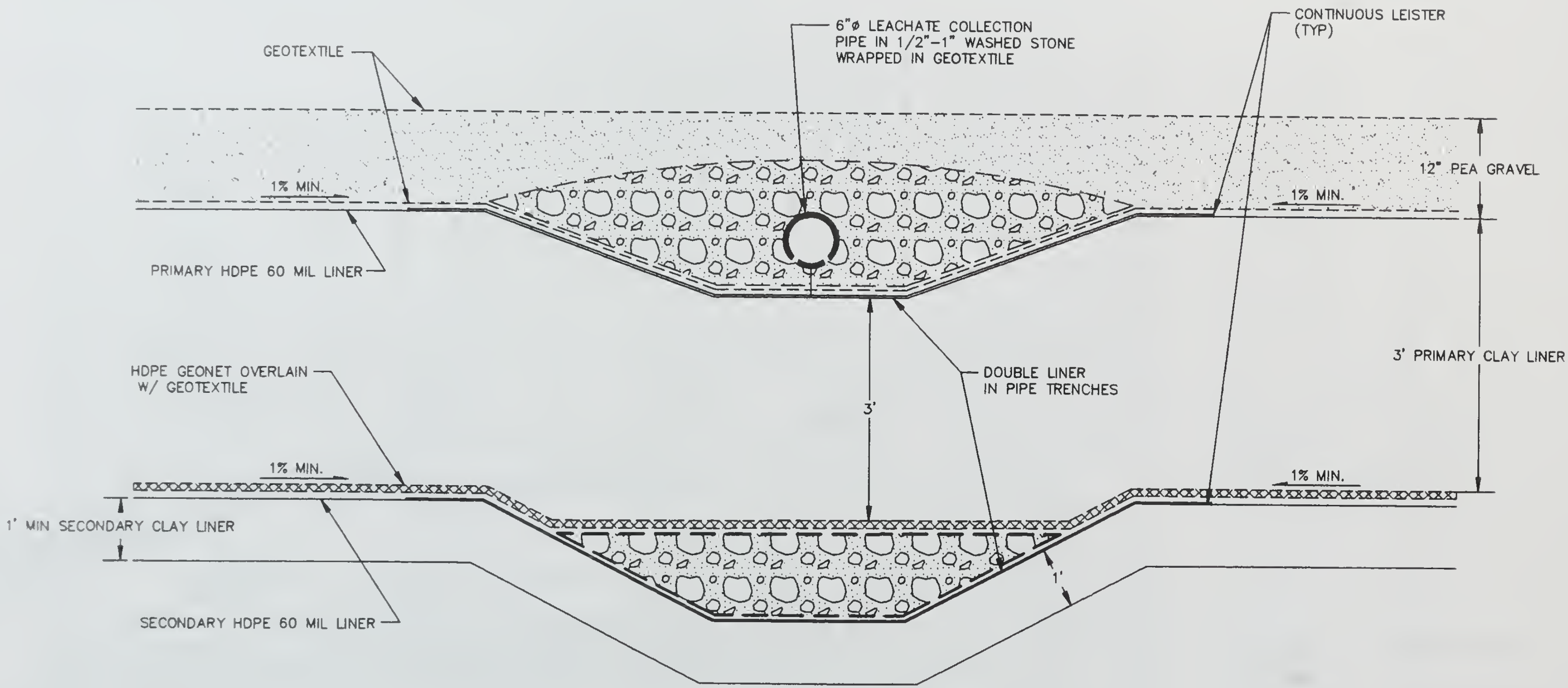
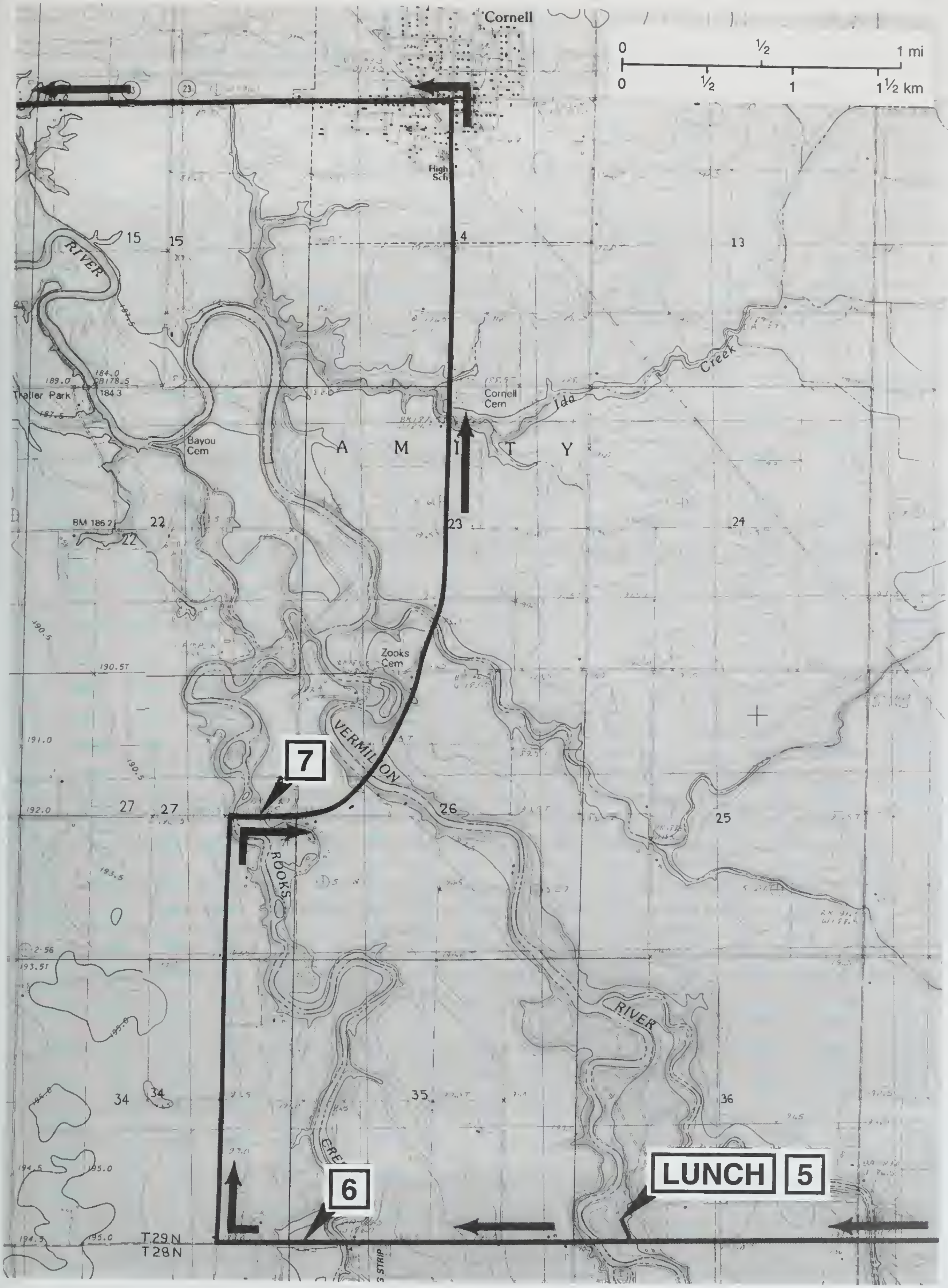


Figure 20 Schematic of center trench detail (courtesy of County Environmnetal, Livingston Landfill).


Cornell
0
½
1 mi
0
½
1
1½ km
High Sch
RIVER
Trailer Park
Bayou Cem
Cornell Cem
Ida Creek
A M I T Y
BM 186.2
Zooks Cem
VERMILION
7
ROOKS
RIVER
LUNCH
5
6
T29N
T28N
15
14
13
22
23
24
27
26
25
34
35
36

STOP 5 LUNCH, ARE YOU HUNGRY? We will stop for lunch at Humiston Woods Nature Center. Following lunch, we will discuss the Vermilion River and glacial deposits at the overlook platform (SE SW SW, Sec. 36, T29N, R4E, 3rd P.M., Livingston County, Northwest Pontiac 7.5-Minute Quadrangle [40088H6]).

Note: When we leave the nature center and turn right onto 2100N, restart your mileage at 0.0.

Differences in the erosional resistance of bedrock materials have produced marked changes in streams and rapids on the larger tributaries, such as the Vermilion River. Tight meanders occur where the Vermilion River flows across limestone. The Vermilion River dramatically changes from a north-northwestward course to a west-southwestward course where it encounters the old Ticona bedrock valley north of this stop. The bedrock is buried, and the streams encounter less resistant glacial and alluvial materials filling the old bedrock valley of the Ticona. In addition, the slope of the valley walls decrease where the Vermilion River crosses the Ticona Valley.

0.0	0.0	Leave Stop 5. Retrace the route to the park entrance and reset mileage to 0.0. STOP (1-way); TURN RIGHT (west) onto 2100N.
0.1	0.1	Cross Vermilion River. Note the till exposed on the left side of the road after you cross the bridge.
0.1	0.2	T-intersection (1100E) from the left. CONTINUE AHEAD.
0.25	0.45	T-intersection (1075E) from the right. CONTINUE AHEAD.
0.55	1.0	CAUTION: narrow bridge, cross Rooks Creek. Pull off onto the right side of the road and park.

STOP 6 We will discuss the abandoned channel of Rooks Creek (SW SW SW, Sec. 35, T29N, R4E, Northwest Pontiac 7.5-Minute Quadrangle [40088H6]).

The Vermilion River and its major tributaries (e.g., Rooks Creek) are classified as mature rivers. One of the factors in making this classification is the development of meanders (fig. 21). The rivers in this area have eroded through the overlying unconsolidated materials to the top of the bedrock. The resistant nature of the Pennsylvanian bedrock has drastically changed the nature of the rivers. They no longer cut downward but migrate back and forth within their confining valleys.

An abandoned channel is located east of the bridge on the north side of the road. Other abandoned channels and the meandering nature of Rooks Creek can be interpreted from topographic maps (see route map). To the right, a *slip-off slope* and a *point bar* have developed on the inside of a stream meander. A steep cutbank is located on the outside of the meander curve (fig. 21). As you look down the road (facing west), there are two distinct rises in the landscape. The lower rise marks the position of an older terrace level along the creek. The upper rise marks the ancient lake bed level of Glacial Lake Pontiac.

0.0	1.0	Leave Stop 6. CONTINUE AHEAD (west).
0.2	1.2	Road ascends slope to the ancient lake bed level of Glacial Lake Pontiac.
0.2	1.4	CAUTION: T-intersection from the right (975E). TURN RIGHT (north) onto 975E.
1.45	2.85	Pull over to the right side of the road and park.

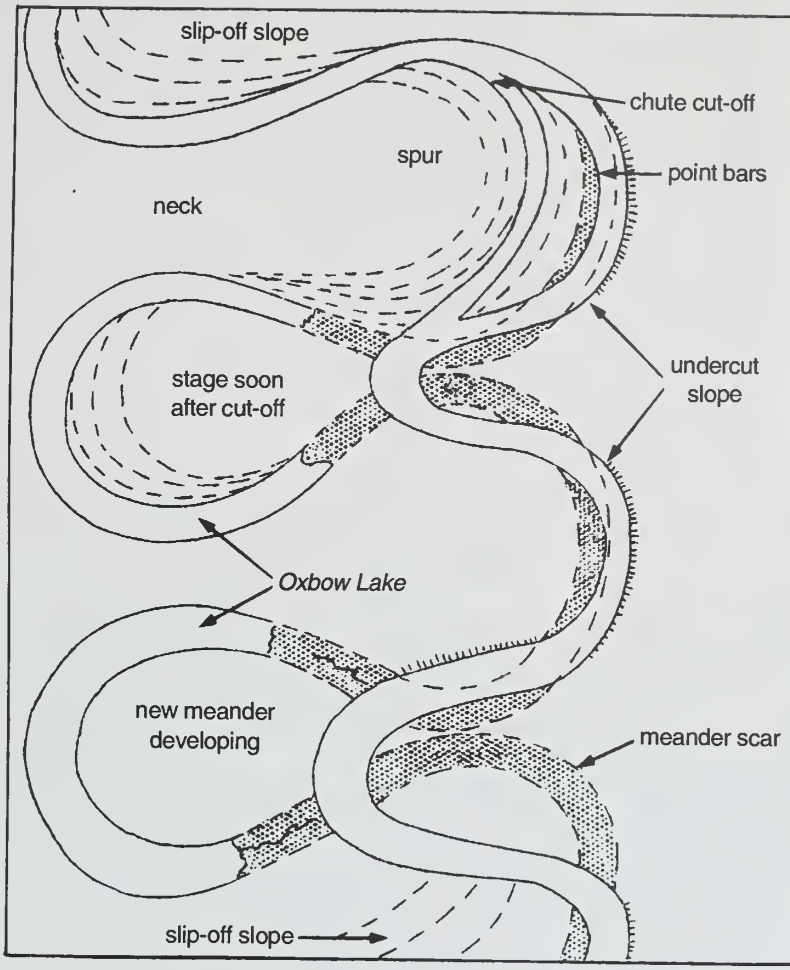


Figure 21 Floodplain features. Water flowing through a meander curve is forced against the outside bank (called the cutbank). As the cutbank is eroded back, the channel migrates in this direction leaving a "slip-off" slope on the inside of the curve. Deposition of material may occur on the slip-off slope in crescent-shaped forms that, when incorporated into the floodplain, become floodplain scrolls. Meanders move across the valley and also downstream. Abandoned meanders generally leave evidence of their existence in the form of meander scars. The area within a meander curve is called a neck. At times of high water, the river may cut off the meander through the neck, leaving a meander core or abandoned meander. If water is left in the cut-off meander, it is called an oxbow lake. When the river cuts through channel bars or point bars, which form on the slip-off slope, a chute cut-off is formed.

STOP 7 We'll discuss the meanders along Rooks Creek (NE NW NE SE, Sec. 27, T29N, R4E, Northwest Pontiac 7.5-Minute Quadrangle [40088H6]).

The creek has developed several meanders (fig. 21) at this location. To the southeast in the distance, just below the barn, is an abandoned meander. On the north side of the road, along the east side of the valley, is a more recent abandoned meander loop of Rooks Creek. Farther east of this meander, still on the north side of the road, is another older abandoned meander that was developed higher up on an older terrace level. The meanders can be identified on topographic maps (see route map). Several ponds and marshy areas are developed in the abandoned meanders of Rooks Creek.

0.0	2.85	Leave Stop 7. Prepare to turn right.
0.05	2.9	STOP (1-way); T-intersection (2250N). TURN RIGHT (east) and cross Rooks Creek.
0.2	3.1	T-intersection from the left (1000E). CONTINUE AHEAD (east); the road curves to the left.
0.2	3.3	T-intersection from the right (1020E). CONTINUE AHEAD, bearing to the left.

0.1	3.4	Cross Vermilion River, which serves as the "base level" for Rooks Creek—that is, Rooks Creek will erode its channel no lower than the level of the Vermilion River at the point of their confluence (slightly more than 1/2 mile northwest of here). The Vermilion is straighter here and does not have discernible terrace levels.
0.4	3.8	Crossroad of intersection of 2300N and 1040E. CONTINUE AHEAD (north). Note: About 0.2 mile to the left, the Pennsylvanian Lonsdale Limestone Member is exposed along the Vermillion River.
0.2	4.0	Cross Baker Run. The Lonsdale Limestone is exposed upstream to the right of the bridge, especially along the northeast bank. The overlying glacial till is thin.
0.7	4.7	Cross Ida Creek.
0.1	4.8	T-intersection from the right (2400N). CONTINUE AHEAD (north). Cornell cemetery is on the right.
0.8	5.6	CAUTION: entering the Village of Cornell.
0.2	5.8	STOP (2-way); crossroad intersection (2500N, SR 23 and 1050E). TURN LEFT (west) onto SR 23.
0.95	6.75	Crossroad intersection (950E, Manville Road and SR 23), 2-way stop from the left and right. CONTINUE AHEAD (west).
0.7	7.45	Valley View Industries main office is on the right side of the road.
0.15	7.6	Cross Vermillion River; Pennsylvanian bedrock is exposed in the west bank. Note: The valley walls along the Vermilion River are higher than those in the area of Pontiac. The river is cutting down more here as it approaches the Illinois River.
0.35	7.95	T-intersection from the left (825E); CONTINUE AHEAD.
0.35	8.3	T-intersection from the left (790E); CONTINUE AHEAD. Road curves to the right.
0.15	8.45	Cross Scattering Point Creek.
0.1	8.55	Abandoned shale pits occur along the left side of the highway.
0.15	8.7	T-intersection from the left (760E). CONTINUE AHEAD and prepare to TURN RIGHT.
0.1	8.8	TURN RIGHT (east) into the Valley View Industries office area. Do NOT block traffic lanes. You MUST have permission to enter this property.


8
Bradley Bridge
Radio Tower
Quarry
Campground
VERMILION
RIVER
Campbell Cem
Springer Cem
STEEL TOWER TRANS LINES
0 1/2 1 mi
0 1/2 1 1/2 km

STOP 8 We'll stop at the Valley View Industries open pit mine in the Farmington Shale Member, Shelburn Formation (NE NW SE, Sec. 8, T29N, R4E, 3rd P.M., Flanagan North 7.5-Minute Quadrangle [40088H7]).

At this stop, you can see an excellent exposure of the Farmington Shale. Shales in the Pennsylvanian are not usually well exposed because they are easily eroded and slumped. The Valley View operation is the only active shale-mining pit in this area.

The Farmington Shale (figs. 11 and 22) is greenish gray, thin bedded, and between 35 and 40 feet thick. It contains numerous reddish to yellowish orange siderite veins oriented both vertically and at various angles across the bedding planes. Thin to medium sandstone lenses are scattered throughout the unit. A medium bedded sandstone in the east wall of the pit has an easterly dip (fig. 23). The dip in this sandstone indicates that the pit is located east of the axis of the La Salle

Figure 22 Farmington Shale exposed in Valley View Industries pit.

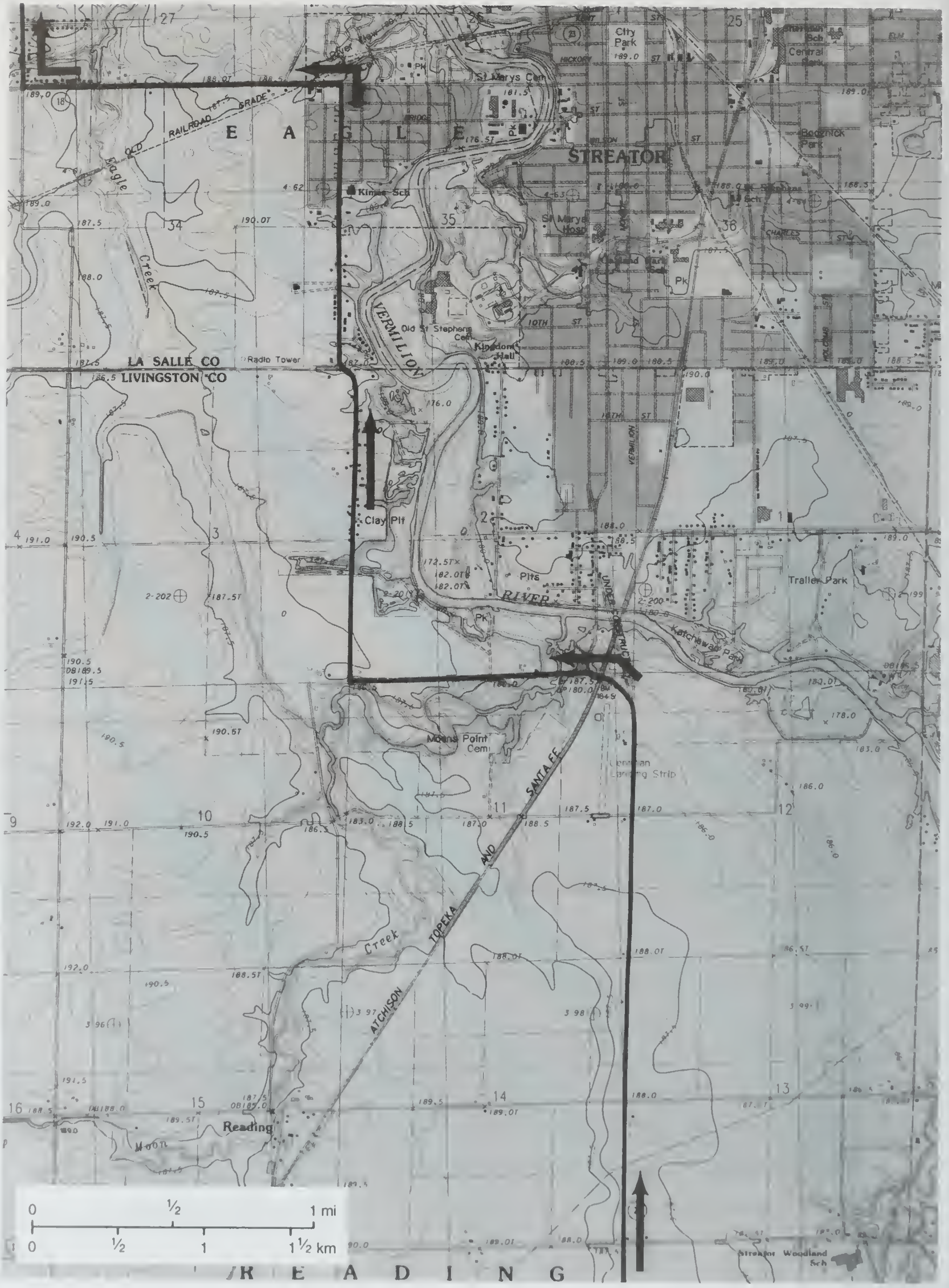
Anticlinorium. The shale also contains numerous siderite concretions throughout the formation. A small scattering of Pennsylvanian fossil plant impressions can be found along the bedding planes within the gray shale. The shale mined here is sold to the Marseilles Brick Company.

0.0	8.8	Leave Stop 8. Retrace route to SR 23 and resume mileage. STOP (1-way). CAUTION: TURN RIGHT (northwest and then west) on SR 23.
0.1	8.9	T-intersection from the right (750E). CONTINUE AHEAD (west).
1.3	10.2	Cross Mole Creek.
0.1	10.3	Crossroad intersection (600E); CONTINUE AHEAD.
0.9	11.2	Road makes 90° turn to the right.
0.15	11.35	T-intersection from the left (2550N). CONTINUE AHEAD (north).
0.25	11.6	T-intersection from the left (2600N, Long Point Spur). CONTINUE AHEAD.
0.55	12.15	T-intersection from the right (2650N). CONTINUE AHEAD.

Rubbly Lonsdale Limestone with overlying sand and gravel is exposed in the bed of Long Point Creek west of the T-road. Lacustrine deposits overlain by gray, pebbly till also occur above the limestone. The till contains pieces of black shale and coal. This shallow stream has been channelized here in an attempt to straighten its course and cause fewer problems with the highway.

0.05	12.2	Cross Long Point Creek.
0.6	12.8	Note that we have returned to the level uneroded lake plain here.

Figure 23 View of Valley View Industries open pit mine in the Farmington Shale Member (looking to the south).

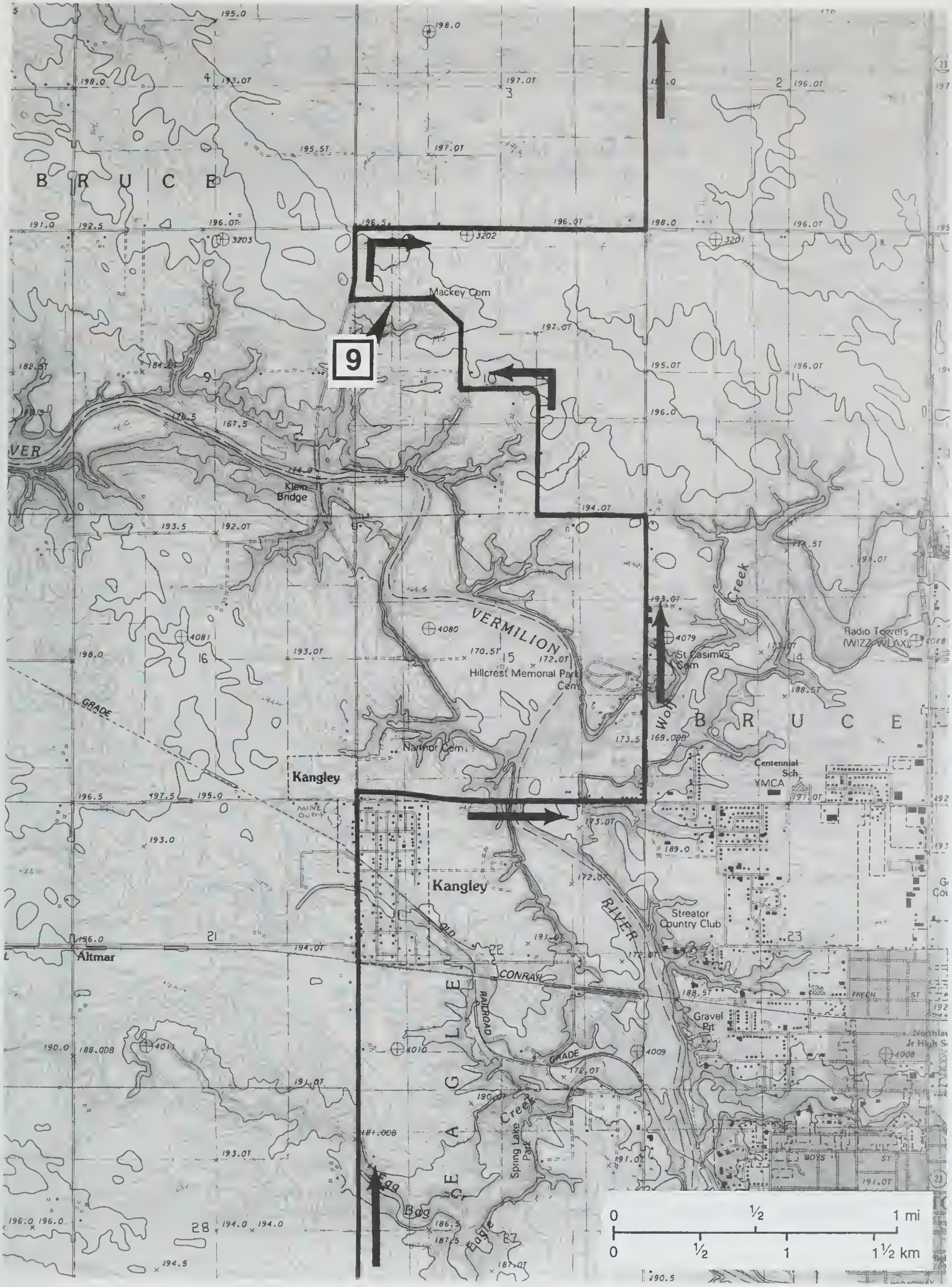

STREATOR
City Park
Central Sch
Bodznick Park
St Marys Cem
St Marys Hosp
Kimes Sch
VERMILION
Old St Stephens Cem
Kingdom Hall
LA SALLE CO
LIVINGSTON CO
Radio Tower
Clay Pit
Pits
RIVER
Katchewan Park
Trailer Park
Moons Point Cem
Landing Strip
ATCHISON TOPEKA AND SANTA FE
Creek
Eagle Creek
OLD RAILROAD GRADE
E A G L E
Reading
Moon
Streator Woodland Sch
R E A D I N G
0 ½ 1 mi
0 ½ 1 1½ km

0.8	13.6	Crossroad intersection (2800N); CONTINUE AHEAD.
0.95	14.55	Cross Prairie Creek.
0.05	14.6	Crossroad intersection from the left (2900N, Ancona Road); CONTINUE AHEAD.
0.95	15.55	STOP (4-way); crossroad intersection (3000N, SR 17 and 500E, SR 23). CONTINUE AHEAD (north) on SR 23.
0.45	16.0	Crossroad intersection (3050N, Reading Road); CONTINUE AHEAD.
1.0	17.0	Crossroad intersection (3150N); CONTINUE AHEAD.
0.2	17.2	Prepare to turn left.
0.15	17.35	USE EXTREME CAUTION: T-intersection from the left 3190N. TURN LEFT onto 3190N from 500E; BEWARE of fast traffic approaching from the railroad overpass just ahead.
0.2	17.55	Passing under an Atchison Topeka and Santa Fe Railroad bridge.
0.05	17.6	T-intersection from the right (480E). CONTINUE AHEAD.
0.1	17.7	Cross Moon Creek. Bedrock is exposed on the left side of the bridge along the east bank of the creek.
0.15	17.85	Entrance to Streator Area Landfill to the right. CONTINUE AHEAD.
0.55	18.4	CAUTION: T-road from the right (400E, Coalville Road). TURN RIGHT (north) onto Coalville Road. Notice the slump on the left side of the road as you make the turn.
0.4	18.8	Old abandoned clay pits are on both sides of the road. The abandoned clay pits have been recycled into landfills. The area to the left is the old landfill. To the right is the active landfill. Notice the groundwater monitoring wells on the left side of the road surrounding the old landfill.
0.65	19.45+	Road curves to the left. BEAR LEFT (northwest) onto North 12th Road and prepare to turn right.
0.1	19.55	CAUTION: T-intersection from the right. TURN RIGHT (north) onto East 1625th Road and enter La Salle County.
0.5	20.05	CAUTION: Entering the City of Streator.
0.1	20.15	STOP (4-way); intersection of Reading St. and Columbus Road. CONTINUE AHEAD (north) on Columbus.
0.15	20.3	STOP (4-way); Intersection of Sundown Street and Columbus Road. CONTINUE AHEAD (north) on Columbus Road.
0.05	20.35	CAUTION: T-intersection from the right (Bridge Street). CONTINUE AHEAD.

0.15	20.5	STOP: T-intersection (Route 18, West Main Street and Columbus Road). TURN LEFT (west) onto West Main Street.
0.2	20.7	T-intersection from the right (East 16th Street). CONTINUE AHEAD.
0.6	21.3	Cross Eagle Creek.
0.3	21.6	CAUTION: Intersection of West Main Street and Kangley Road. TURN RIGHT (north). Note: Kangley Road is County 29 and East 15th Road.
0.8	22.4	Cross Egg Bag Creek.
0.6	23.0	CAUTION: Railroad crossing (Conrail, 1 track); entering community of Kangley. CONTINUE AHEAD (north) on Section Street.
0.6	23.6	STOP (3-way): T-intersection (15N and 15E); TURN RIGHT (east). This is La Salle County Rt. 29.

Northwest of this intersection, the ground surface is covered by sinkhole topography. This is the result of subsidence over a mined-out area. Speckled soil patterns can be recognized from aerial photography. The collapse of former mine workings (sinks) often show up as dark spots on aerial photographs, and they can be identified as wet areas from ground observations.

0.4	24.0	Starting descent into Vermilion River Valley. This is a point of great incision. Exposure of Pennsylvanian bedrock occurs on the west bank.
0.1	24.1	Cross Vermilion River. Note the high bank on the west and the slip-off slope on the east. The Vermilion has eroded a broad valley at this point. The bedrock exposed on the west side of the valley consists of thin-bedded shales with a few sandstone stringers (thin discontuous beds). The top of the exposure is capped by 1 to 2 feet of sandstone that forms a ledge.
0.2	24.3	Ascend east valley wall of Vermilion River.
0.25	24.55	T-intersection from the left (East 16th Road). TURN LEFT (north) onto East 16th, descending into Wolf Creek Valley.
0.2	24.75	Cross Wolf Creek. This is a very large, broad valley through here—a nice example of a floodplain and development of a double terrace. The terrace on the south side of the creek is lower than the terrace on the north side of the creek. The southern terrace is younger than the northern terrace.
0.15	24.9	Ascend north valley wall.
0.65	25.55	T-intersection from the left (North 16th and East 16th Roads); TURN LEFT (west). Note: The topography of this area is the result of the development of streams cutting down to the Vermilion River.
0.35	25.9	Road makes 90° turn to the right (north). Note: The road is now marked as E1553 Road.
0.25	26.15	Road turns to gravel. In the ravine to the left are possible spoil piles from earlier mining operations.


B R U C E
Mackey Cem
9
Klein Bridge
VERMILION
Hillcrest Memorial Park Cem
Narnor Cem
St Casimirs Cem
Wolf Creek
Radio Towers (WIZZ-WLAX)
Centennial Sch
YMCA
Kangley
Kangley
MINE DUMP
GRADE
Altmar
OLD RAILROAD GRADE
CONRAIL
RIVER
Streator Country Club
Gravel Pit
Northlawn Jr High Sch
EAGLE
Eagle Creek
Spring Lake Park
Egg Bag
FRENCH ST
BOYS ST
0 ½ 1 mi
0 ½ 1 1½ km

0.15	26.3	Road takes a 90° turn to the left (west). Notice the gob pile as you make the turn. The surface of the land contains numerous depressions, most likely the result of mine subsidence.
0.3	26.6	Road curves 90° to the right and heads north. On the right is the remains of an old house foundation. This site experienced mine subsidence damage.
0.05	26.65	View of the large gob pile to the left.
0.15	26.8	Road curves to the left.
0.1	26.9	Entrance to Mackey Cemetery. Note: Immediately past the cemetery on the left side of the road is a small circular depression, most likely the result of mine subsidence. A second circular depression of equal size is located 1/2 mile west of the first depression.
0.1	27.0	Pull over to the right side of the road and park.

STOP 9 We'll view a gob pile and discuss coal resources and mining in the Streator area (SW SE NW NW, Sec. 10, T31N, R3E, Streator North 7.5-Minute Quadrangle [41088B7]).

Located within a radius of 2 miles of here are 18 known abandoned coal mines (fig. 24). To the southeast, we can easily see the large spoil pile (fig. 25) from a mine that operated in the first half of the 1900s. The red color of the pile is the result of oxidation of the iron in the clay or shale. This particular mine operated in two coal members of the Carbondale Formation (fig. 11)—the Herrin Coal, which is roughly 80 feet deep and 4 to 9 feet thick, and the Colchester Coal, which is 212 feet deep and 3 feet thick. Most of the mines in this area operated in these coals. These mines were mostly of the shaft (vertical access) and slope (inclined access) type. The shaft mines were primarily found in the uplands for the Herrin and Colchester Coals. The slope mines operated mostly in the Herrin Coal and were found at the base of the bluffs along the Vermilion River and the deep ravines that drain into the valley. To the south of the gob piles, the Herrin Coal was closer to the surface, and the companies were able to drive slope entrances for their mines. We have records of at least one small strip mine operated in the Vermilion River Valley just a mile southwest of here. From 2.5 to 8.5 feet of Herrin was mined at a depth of 20 to 30 feet.

Records also indicate that, just 3/4 mile southwest of here, a small-scale shaft mine was operated at a depth of 40 feet in the Houchin Creek Coal (fig. 11). The Houchin Creek Coal in this mine was only 1.8 feet thick. As the above statements indicate, the Herrin Coal is quite variable in thickness, ranging from roughly 9 to 2.5 feet thick. In this part of the state, the Herrin Coal has this variation over such short distances because the thicker coal represents areas of thick peat accumulation in abandoned channels. Depths to the coal vary from less than 20 feet to more than 120 feet, depending on whether you are in the valley (where the coal has less overburden) or in the uplands.

The Houchin Creek Coal lies about 60 to 70 feet above the Colchester. It was nearly 2 feet thick in the only mine to exploit it but, over most of the area of La Salle and Livingston Counties, it is only 4 inches or less thick (such as at our last stop of the day). To the south and east, however, the Houchin Creek near Streator may be as thick as 3 feet in some isolated areas.

The Colchester Coal occurs about 120 to 140 feet below the Herrin and is fairly uniform in thickness, averaging 3 feet throughout most of the area. The Colchester Coal, Herrin Coal (Carbondale Formation), and Danville Coal (Shelburn Formation) (fig. 11) constitute the main coals exploited in

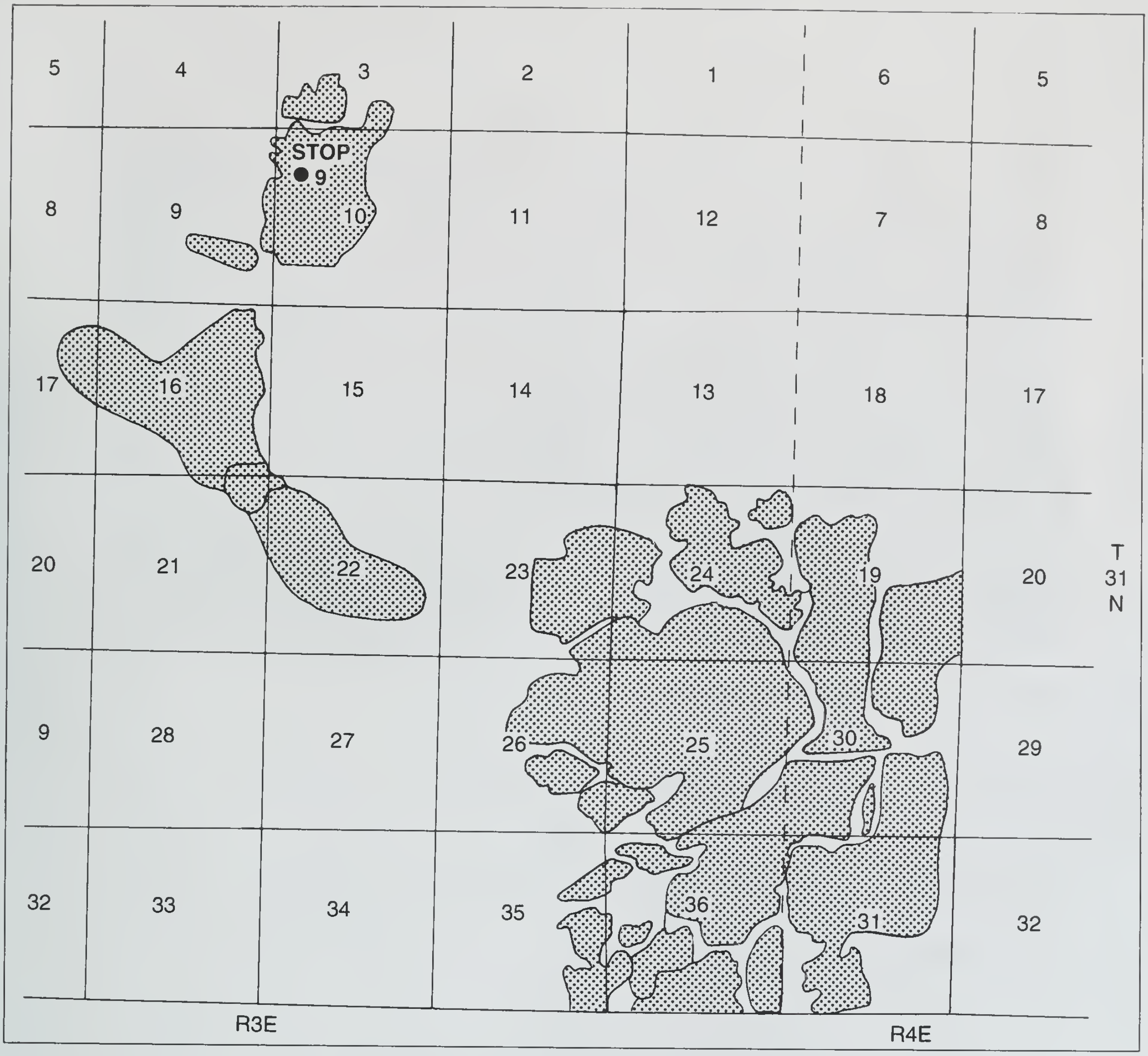


Figure 24 Mined out areas in the vicinity of Stop 9.

this region over the last 100 years. Coals such as the Houchin Creek and others were only minor seams in terms of mining.

We estimate that there are still some 41 million tons of Herrin Coal resources and 63 million tons of Colchester Coal resources present in the township (T31N, R3E; fig. 24). The small patch of Houchin Creek Coal present is estimated to contain perhaps 25 million tons of resources. We estimate the following coal resources for all of La Salle County: Herrin, 241 million tons; Houchin Creek, 45 million tons; and Colchester, 1,322 million tons. Not all of these resources are minable, however, given current economic and technologic restraints.

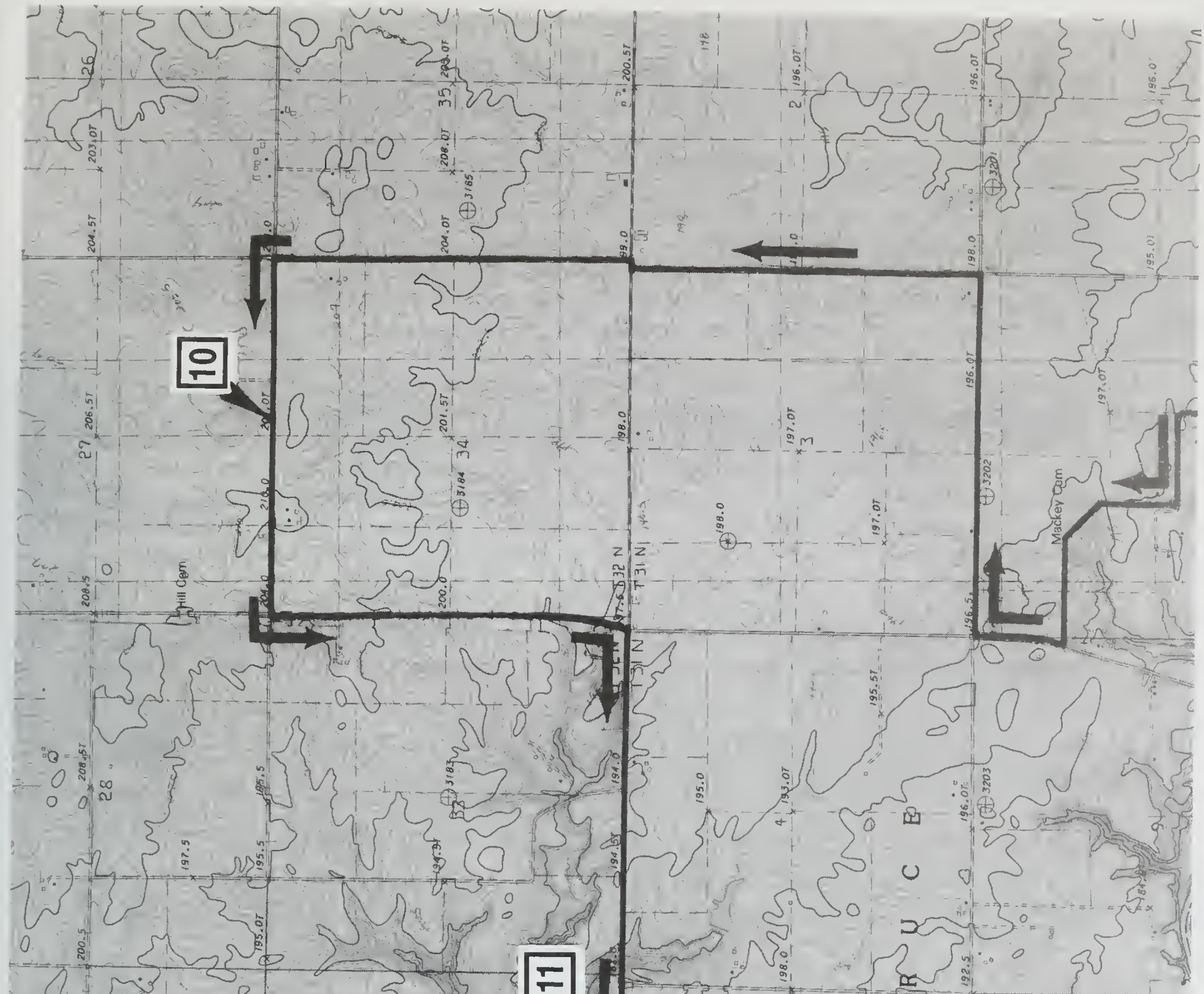
0.0	27.0	Leave Stop 9. CONTINUE AHEAD.
0.2	27.2	STOP (1-way) at T-intersection (East 15th and N1553 Roads). TURN RIGHT (north).

Figure 25 View of gob piles to the southeast of Stop 9.

0.25	27.45	STOP (1-Way) at the T-intersection (East 15th and North 17th Roads). TURN RIGHT (east).

When you make the turn, you will see (on the north side of the road) an overgrown area of shrubs and trees. This is the site of the old Heenenville Coal Mine.

0.75	28.2	You are now travelling across the relatively flat bottom of Glacial Lake Ancona. The relief here is only 2 to 3 feet.
0.25	28.45	Crossroad intersection (East 16th and North 17th Roads). TURN LEFT (north) onto the gravel road. The topographic expression in the horizon ahead is the Farm Ridge Moraine. We are travelling up a very gentle sloping shoreline feature of Glacial Lake Ancona.
0.95	29.4	Crossroad intersection (East 16th and North 18th Roads, La Salle County Rt. 5). Road jogs to the RIGHT and then immediately to the LEFT. Straight ahead is the shoulder marking the location of the old shoreline of Lake Ancona.
0.5	29.9	The shoulder that represents the Lake Ancona shoreline is just past the old corn crib on the left. Continue ascent of the Farm Ridge Moraine.
0.35	30.25	Crest of Farm Ridge Moraine, directly across from the farm house. You will begin to see undulating moraine topography.
0.1	30.35	STOP (2-Way): Intersection of North 19th and East 16th Roads. TURN LEFT (west). This road traverses the crest of the Farm Ridge Moraine.
0.45	30.8	Pull over to the right side of the road and park.


10
END
11
Hill Cem
Mackey Cem
B R U C E
VERM
0
½
1 mi
1½ km

STOP 10 We will discuss the development of moraines and kettles and their topographic expression (SW SW SE, Sec. 27, T32N, R3E, Streator North 7.5-Minute Quadrangle [41088B7]).

The topography of the Farm Ridge Moraine (fig. 14) is referred to as knob-and-kettle topography. The surface relief of moraines is generally greater than that of drift plains (fig. 26). A good example of surface relief can be seen on the north side of the road, west of the old barn. This boggy area is a kettle hole (fig. 26) that developed in the moraine when a block of ice buried by glacial till melted. There are a couple of larger kettle holes farther to the west of this one. A large number of depressions are illustrated on the topographic map for this area (see route map). The depressions are outlined on the map by the contours with short perpendicular line segments that point inward.

As the Wisconsinan glacier retreated, the ice withdrawals and readvances created a complex sequence of landforms in northeastern Illinois. The most outstanding of these are end moraines, which are caused by the accumulation of drift at the ice margin when the rate of advance and the rate of melting of a glacier are essentially in balance (fig. 26). As more and more rock debris is brought to the edge of the glacier, it piles up and forms a ridge. At some places, there are large gaps in the moraines where subglacial streams presumably carried away most of the drift. The flatter areas behind end moraines are called ground moraines or till plains (fig. 26). More than 50 successive end moraines were formed by the Wisconsinan glacier in Illinois alone.

The importance of the Pleistocene Epoch is emphasized by the rich soils formed from the glacial deposits and by the abundant deposits of sand and gravel. The state would not have these valuable resources if the glaciers had not invaded Illinois.

A more detailed description of the glacial history and glacial deposits can be found in the supplementary reading *Pleistocene Glaciations in Illinois* in the back of the guidebook.

0.25	31.05	To the right (north) is another kettle just beyond the break in slope and behind the metal storage buildings.
0.3+	31.35	STOP (1-way): Crossroad intersection of North 19th and East 15th Roads. TURN LEFT (south) onto the blacktop (East 15th Road).
0.2	31.55	Overlook to the south at the farm lane on the right side of the road. We are about 0.35 mile southwest of the crest of the Farm Ridge Moraine and about 20 feet lower. The view to the south is across the bed of Glacial Lake Pontiac.
0.75	32.3	STOP (2-way): Crossroad intersection of N18th (Leonore Road) and East 15th Road. TURN RIGHT (west) onto North 18th Road.
0.5	32.8	T-intersection from the left (East 14th Road). CONTINUE AHEAD.
0.75	33.55	CAUTION: Pull over to the right as far off the road as you safely can. THE DITCH IS DEEP. BE ALERT—traffic is fast and visibility is limited! Note: A smaller group could use the parking lot at the base of the hill on the left side of the road.

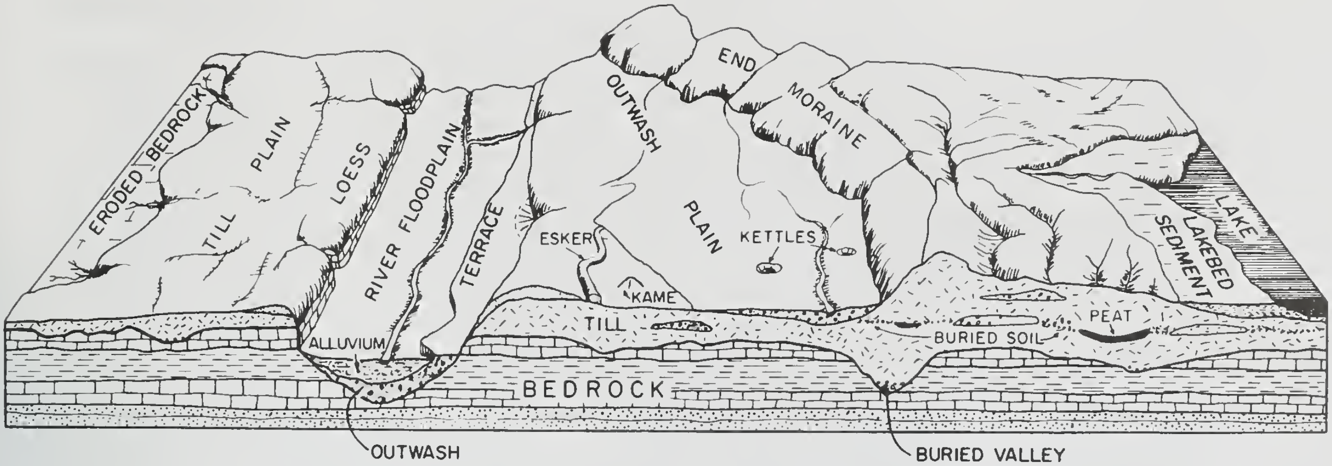


Figure 26 Block diagram showing relationship of glacial and alluvial deposits to landforms and bedrock surface (modified from Piskin and Bergstrom 1975).

STOP 11 We'll discuss the relationship between the LaSalle Anticlinorium and Pennsylvanian cyclic sedimentation at Sandy Ford (SW SE, Sec. 32, T32N, R3E, Leonore 7.5-Minute Quadrangle [41088B8]).

Pennsylvanian rocks (fig. 11) are exposed at the base of the hill on the north side of the bridge along the Vermilion River and in a small tributary from the east. For access, walk under the bridge and follow the path on the north side of the creek. We will discuss the strata starting with the Vermilionville Sandstone and work down-section to the Pleasantview Sandstone along the creek.

Here, you can see the interplay between the elevation of the La Salle Anticlinorium and the Pennsylvanian cyclic deposition, which was controlled by the changes in sea level. The rock units present (fig. 27), starting from the top, include the Vermilionville Sandstone underlain by the Canton shale, the Covell conglomerate, the Hanover Limestone, the Excello Shale, the Houchin Creek (No. 4) Coal, and the Houchin Creek underclay.

The overall thickness of these units at this stop are greatly abbreviated when compared with the same units deposited to the west of the La Salle Anticlinorium. The thicknesses of underclays and coals were strongly influenced by the anticlinorium. This is evident in that the Houchin Creek (No. 4) Coal is very thin, and the Springfield (No. 5) Coal and underclay, which normally occur above the Covell conglomerate and below the Vermilionville Sandstone, are totally absent while the underclay of the Houchin Creek Coal is of normal thickness. The normal thickness of the Houchin Creek underclay suggests that the elevations of the anticline and surrounding areas were nearly the same. In the case of the thin to absent units, the elevation of the anticlinorium was high enough during the deposition of the Houchin Creek (No. 4) Coal and the underclay and Springfield (No. 5) Coal that swamps were poorly developed or did not form at all.

The water was deep enough that the anticlinorium did not affect the accumulation of the black muds that formed the Excello Shale. The types and abundance of fossils in the phosphatic black shales suggest that the anticlinorium was a elevated feature on the sea floor, and it caused an upwelling of nutrient-rich currents. The sea regressed slowly enough that the overlying Hanover Limestone was deposited in a gradually shallowing sea along the anticlinorium. The subspherical mounds near the top of the Hanover are algal heads. The presence of the algal heads and the types of organisms preserved in the Hanover indicate that the sea floor was elevated and that the ocean water was warm. The final phase of regression of the sea produced the extremely shallow water in which the Covell conglomerate was deposited. At this time, wave and current action produced extreme brecciation of

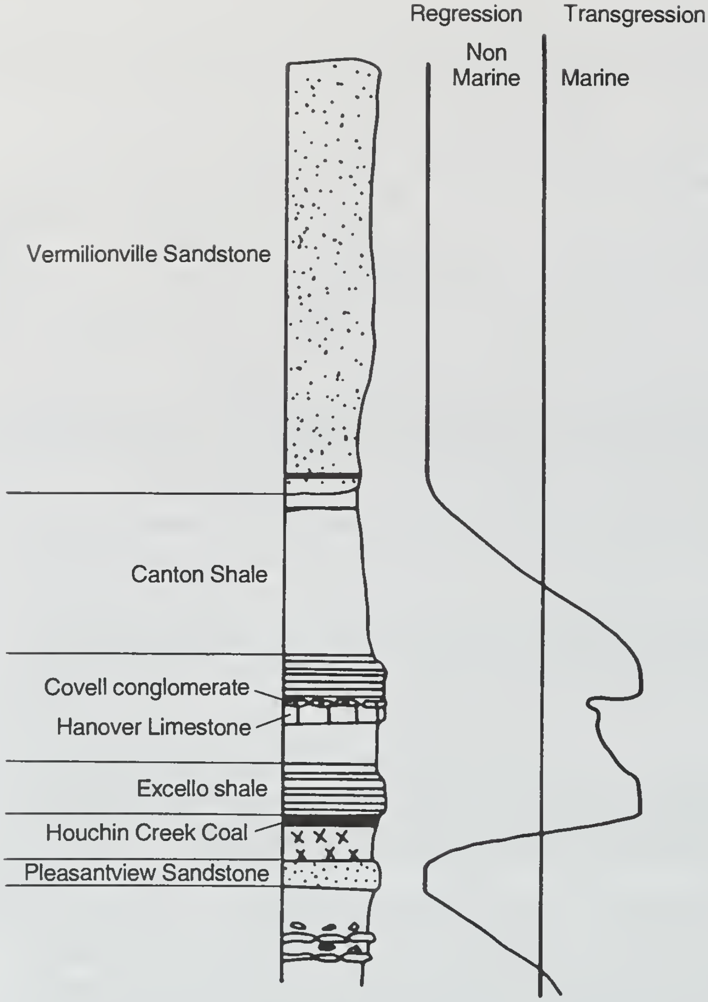


Figure 27 Stratigraphic section at Sandy Ford along the east side of the Vermilion River, SW SE, Sec. 32, T32N, R3E. Modified from R.S. Nelson et al.1988.

limestone sediments and organisms. Following deposition of the black shale, marine regression was so rapid that the conditions necessary for deposition of the St. David Limestone did not occur along the anticlinorium. The anticlinorium appears to have had little influence on the deposition of the sandstones.

After looking at the Pennsylvanian rocks, we will also have an opportunity to collect marine fossils from the Hanover Limestone and the Excello Black Shale. Some especially well-preserved clam and brachiopod fossils can be found in the Excello Black Shale. These are fossils of some of the marine organisms that flourished in the shallow Pennsylvanian seas some 280 million years ago.

END OF FIELD TRIP

We hope you enjoyed this excursion and found the geology of the area around Pontiac and Streator to be interesting and educational. Have a safe journey home! Join us in Carbondale on October 28 for more exciting and fun-filled adventures.

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GLOSSARY

The following definitions are from several sources in total or in part, but the main reference is: Bates, R.L., and J.A. Jackson, eds., 1987, Glossary of Geology: American Geological Institute, Alexandria, VA, 3rd Ed., 788 p.

Ablation — Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.

Age — An interval of geologic time; a division of an epoch.

Aggrading stream — One that is actively building up its channel or floodplain by being supplied with more load than it can transport.

Alluviated valley — One that has been at least partially filled with sand, silt, and mud by flowing water.

Alluvium — A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta, etc.

Anticline — A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

Aquifer — A geologic formation that is water-bearing and which transmits water from one point to another

Argillaceous — Largely composed of clay-sized particles or clay minerals.

Base level — Lowest limit of subaerial erosion by running water, controlled locally and temporarily by water level at stream mouths into lakes or more generally and semipermanently into the ocean (mean sea level).

Basement complex — Largely crystalline igneous and/or metamorphic rocks of complex structure and distribution that underlie a sedimentary sequence.

Basin — A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments.

Bed — A naturally occurring layer of Earth material of relatively greater horizontal than vertical extent that is characterized by a change in physical properties from those overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a watercourse or of a stream channel.

Bedrock — The solid rock underlying the unconsolidated (non-indurated) surface materials.

Bedrock valley — A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

Braided stream — A low gradient, low volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide, and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load.

Calcarenite — Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.

Calcareous — Containing calcium carbonate (CaCO3); limy.

Calcite — A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs' scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

Chert — Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint but lighter in color.

Clastic — Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.

Closure — The difference in altitude between the crest of a dome or anticline and the lowest contour that completely surrounds it.

Columnar section — A graphic representation in a vertical column of the sequence and stratigraphic relations of the rock units in a region.

Conformable — Layers of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

Delta — A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.

Detritus — Material produced by mechanical disintegration.

Disconformity — An *unconformity* marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.

Dolomite — A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]_2$); applied to those sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid.

Drift — All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

Driftless Area — A 10,000 square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.

End moraine — A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

Epoch — An interval of geologic time; a division of a period.

Era — A unit of geologic time that is next in magnitude beneath an eon; consists of two or more periods.

Fault — A fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another.

Flaggy — Tending to split into layers of suitable thickness for use as flagstone.

Flood plain — The surface or strip of relatively smooth land adjacent to a stream channel that has been produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

Fluvial — Of or pertaining to a river or rivers.

Formation — The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), usually derived from geographic localities.

Fossil — Any remains or traces of once living plant or animal specimens that are preserved in rocks (arbitrarily excludes Recent remains).

Geology — The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.

Geophysics — Study of the Earth by quantitative physical methods.

Glaciation — A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

Glacier — A large, slow-moving mass of ice at least in part on land.

Gradient — A part of a surface feature of the Earth that slopes upward or downward; a slope, as of a stream channel or of a land surface.

Igneous — Said of a rock or mineral that solidified from molten or partly molten material, i.e., from magma.

Indurated — A compact rock or soil hardened by the action of pressure, cementation, and especially heat.

Joint — A fracture or crack in rocks along which there has been no movement of the opposing sides.

Karst — Area underlain by limestone having many sinkholes separated by steep ridges or irregular hills. Tunnels and caves resulting from solution by groundwater honeycomb the subsurface.

Lacustrine — Produced by or belonging to a lake.

Laurasia — A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is Pangea. The protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay, and geologic features on opposite sides of these zones are very similar.

Limestone — A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite).

Lithify — To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.

Lithology — The description of rocks on the basis of color, structures, mineral composition, and grain size; the physical character of a rock.

Local relief — The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.

Loess — A homogeneous, unstratified deposit of silt deposited by the wind.

Magma — Naturally occurring mobile rock material or fluid, generated within Earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes.

Meander — One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.

Meander scars — Crescent-shaped, concave marks along a river's floodplain that are abandoned meanders, frequently filled in with sediments and vegetation.

Metamorphic rock — Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (gneisses, schists, marbles, quartzites, etc.).

Mineral — A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form.

Moraine — A mound, ridge, or other distinct accumulation of...glacial drift, predominantly till, deposited...in a variety of topographic landforms that are independent of control by the surface on which the drift lies.

Morphology — The scientific study of form, and of the structures and development that influence form; term used in most sciences.

Natural gamma log — These logs are run in cased, uncased, air, or water-filled boreholes. Natural gamma radiation increases from the left to the right side of the log. In marine sediments, low radiation levels indicate non-argillaceous limestone, dolomite, and sandstone.

Nonconformity — An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.

Outwash — Stratified drift (clay, silt, sand, gravel) that was deposited by meltwater streams in channels, deltas, outwash plains, on floodplains, and in glacial lakes.

Outwash plain — The surface of a broad body of outwash formed in front of a glacier.

Oxbow lake — A crescent-shaped lake in an abandoned bend of a river channel.

Pangea — A hypothetical supercontinent; supposed by many geologists to have existed at an early time in the geologic past, and to have combined all the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated

continents, Pangea was supposed to have split into two large fragments, Laurasia on the north and Gondwana on the south. The proto-ocean around Pangea has been termed Panthalassa. Other geologists, while believing in the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.

Ped — A naturally formed unit of soil structure (e.g., granule, block, crumb, or aggregate).

Peneplain — A land surface of regional proportions worn down by erosion to a nearly flat or broadly undulating plain.

Period — An interval of geologic time; a division of an era.

Physiography — The study and classification of the surface features of Earth on the basis of similarities in geologic strucure and the history of geologic changes.

Physiographic province (or division) — (1) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (2) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

Point bar — A low arcuate ridge of sand and gravel developed on the inside of a stream meander by slow accumulation of sediment as the stream channel migrates toward the outer bank.

Radioactivity logs — Logs of bore holes obtained through the use of gamma logging, neutron logging, or combinations of the several radioactivity logging methods.

Relief — The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region; "high relief" has great variation; "low relief" has little variation.

Sediment — Solid fragmental material, either inorganic or organic, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on Earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g, sand, gravel, silt, mud, till, loess, alluvium.

Sedimentary rock — A rock resulting from the consolidation of loose sediment that has accumulated in layers (e.g., sandstone, siltstone,limestone).

Shoaling — The effect of a near-coastal sea bottom on wave height; it describes the alteration of a wave as it proceeds from deep water into shallow water. The wave height increases as the wave arrives on shore.

Sinkholes — Small circular depressions that have formed by solution in areas underlain by soluble rocks, most commonly limestone and dolomite.

Slip-off slope — Long, low, gentle slope on the inside of a stream meander.

Stage — Geologic time-rock unit; the strata formed during an age.

Stratigraphy — The study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata.

Stratigraphic unit — A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

Stratum — A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary bed.

Subage — An interval of geologic time; a division of an age.

Substage — Geologic time-rock unit; a division of a stage. The strata formed during a subage.

Syncline — A downfold of strata which dip inward from the sides toward the axis; youngest rocks along the axis; the opposite of anticline.

System — The largest and fundamental geologic time-rock unit; the strata of a system were deposited during a period of geologic time.

Tectonic — Pertaining to the global forces involved in, or the resulting structures or features of Earth's movements.

Tectonics — The branch of geology dealing with the broad architecture of the upper (outer) part of Earth's crust; a regional assembling of structural or deformational features, their origins, historical evolution, and mutual relations.

Temperature-resistance log — This log, run only in water, portrays the earth's temperature and the quality of groundwater in the well.

Till — Unlithified, unsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogeneous mixture of different sizes and kinds of rock fragments.

Till plain — The undulating surface of low relief in the area underlain by ground moraine.

Topography — The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

Unconformable — Having the relation of an unconformity to underlying rocks and separated from them by an interruption in sedimentation, with or without any accompanying erosion of older rocks.

Unconformity — A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

Valley trains — The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.

Water table — The upper surface of a zone of saturation.

Weathering — The group of processes, chemical and physical, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 2
October 1974

ERRATICS ARE ERRATIC

Myrna M. Killey

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks—are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.

An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

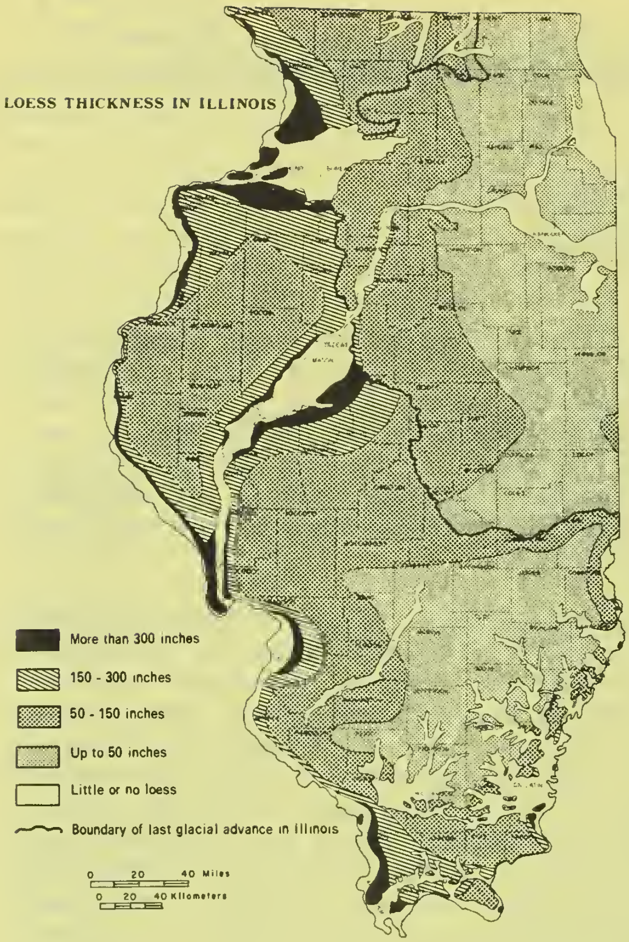
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny



limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 6
October 1975

DO YOU LIVE ABOVE AN UNDERGROUND RIVER?

Myrna M. Killey

Do you think of an underground river as a hidden stream rushing through a tunnel in solid rock? Such subterranean rivers do exist in some states—in Alabama and Missouri, for example. In Illinois, however, except in a few areas where water flows through cracks and channels it has created by dissolving the limestone bedrock, underground "rivers" are not really rivers at all. The Mahomet "river" that underlies part of east-central Illinois is a good example. So is the eastern part of this "river," which is called the Teays (rhymes with "days"). Such rivers are vital to many towns, for they are a reliable source of water.

The Mahomet-Teays river system was discovered more than 25 years ago when numerous water wells were drilled in the eastern and midwestern United States. The story of this vast river system has been pieced together largely from information obtained from records made during the drilling of the wells.

More than a million years ago, before the glaciers of the Great Ice Age crept down over the Midwest, a river as large as the present Mississippi flowed generally westward from its probable source in the mountains of West Virginia, crossed Ohio and Indiana, and traversed east-central Illinois from Hoopeston to Havana. At Havana it joined another ancient river system that occupied what is now the Illinois River Valley (see map). All along its course it cut a deep valley in the bedrock.

When the successive glaciers invaded Illinois from Canada, the fringes of the ice melted during the warmer periods, and the water (meltwater) carried with it great quantities of sand and gravel that had been embedded in the ice. This material, called *outwash*, was deposited in thick layers in the Mahomet Valley. As the later glaciers advanced southward, both the valley and its outwash were buried by ice. When the ice finally melted, tremendous amounts of unsorted rock debris (pebbly, sandy clay called *till*) that had been held in the ice blanketed the land surface, including the former river valley, to depths of 50 to more than 100 feet. (The outwash and till deposits are collectively called *drift*.) The great Mahomet River Valley was obliterated from the landscape and the river no longer existed. Instead, on the new land surface the river patterns we know today developed.

The buried Mahomet Valley is invaluable to east-central Illinois because its porous sand and gravel deposits act as vast underground sponges, storing the rainwater that seeps downward from the land surface. Water flows easily through the sand and gravel into wells drilled in the porous materials. In contrast, glacial till is too fine-grained to allow the water it holds to flow easily and, therefore, cannot supply large amounts of water to wells. Towns such as Hoopeston, Champaign-Urbana, Mahomet, Monticello, and Clinton that are situated above the buried Mahomet Valley have large ground-water supplies available to them, but towns away from the valley have more difficulty obtaining their water. Perhaps the term "underground river" is still applied to the Mahomet Valley because it is easier to imagine great volumes of well water coming from a river than from beds of sand and gravel in a buried valley.

The Mahomet Valley has been traced for about 150 miles across Illinois, it lies at an average depth of more than 200 feet below land surface, and its bottom is at an average elevation of 350 feet above sea level. In some places the ancient valley varies in width from 5 miles at the Indiana line to almost 10 miles near Clinton in De Witt County.

Another major "underground river" is the Princeton Bedrock Valley in the north-central part of Illinois. Many smaller bedrock valleys in the state contain sand and gravel deposited by glacial meltwater. The Mississippi, Illinois, Kaskaskia, and Wabash Rivers also contain beds of outwash deposited by glacial meltwaters, but their courses were not obliterated by the glaciers, and their valleys have remained open as drainageways.

The water supplies in these deposits in the ancient river valleys of Illinois are one of many resources contributing to the state's natural wealth. Of the 3.3 billion gallons of water a day used by Illinois, about 450 million gallons are pumped from sand and gravel deposits, mainly of glacial origin. The value of ground water from these deposits is over $115 million per year.

Do you live above an underground "river"? Look at the map and see. Locate the source of the water you use in your town. If you should see a well being drilled, stop and ask if you can look at the earth materials brought up from the well. These are the kinds of material used to interpret the geologic history of Illinois.

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

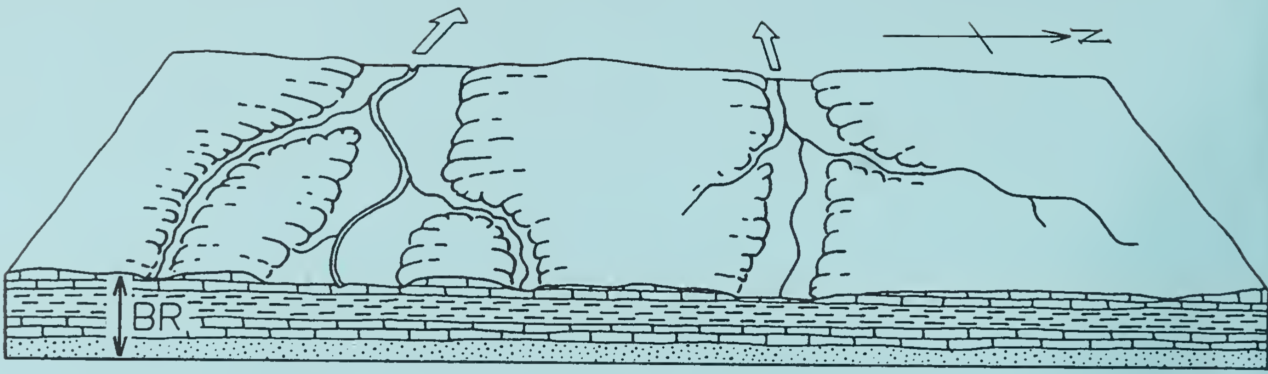
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

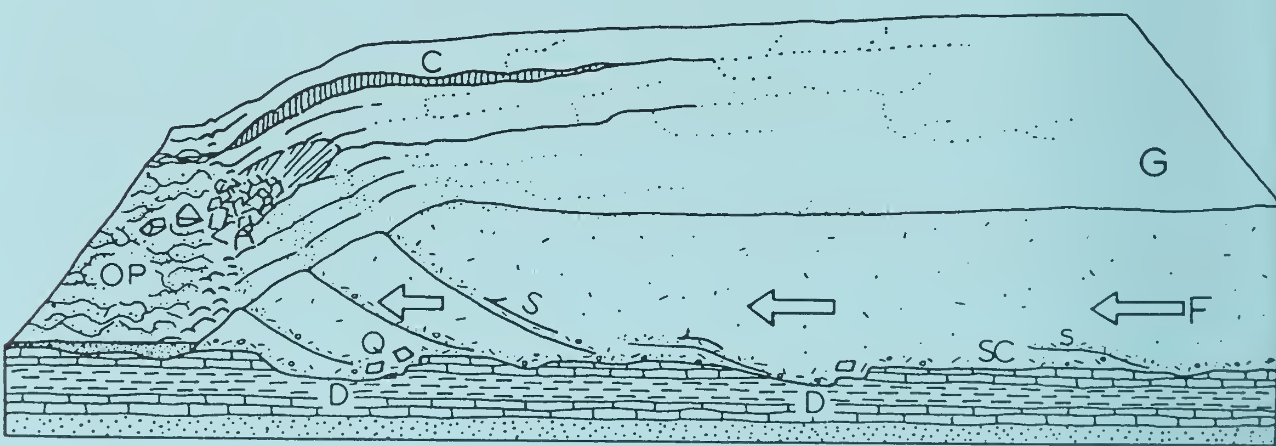
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

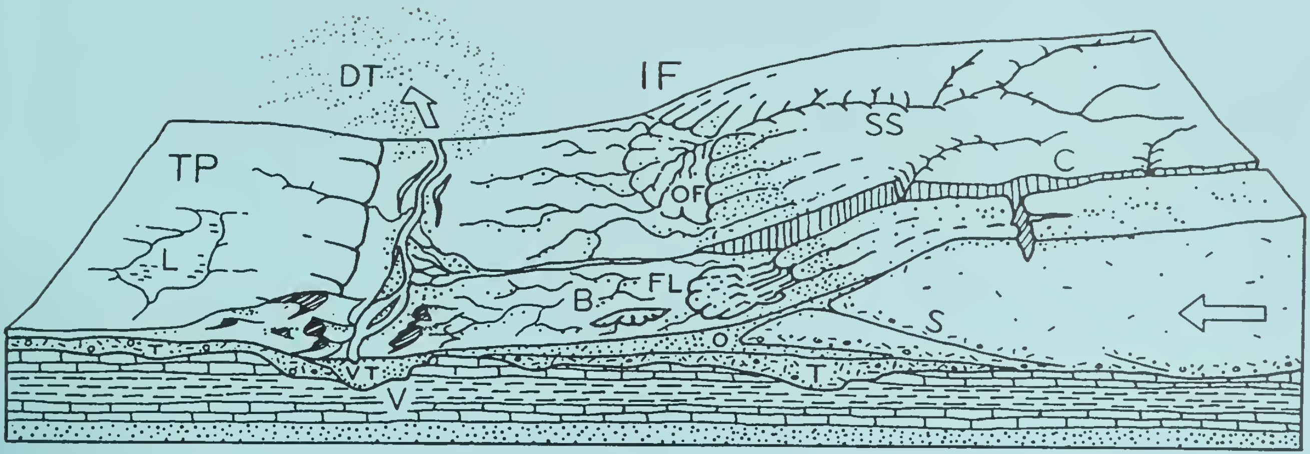
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



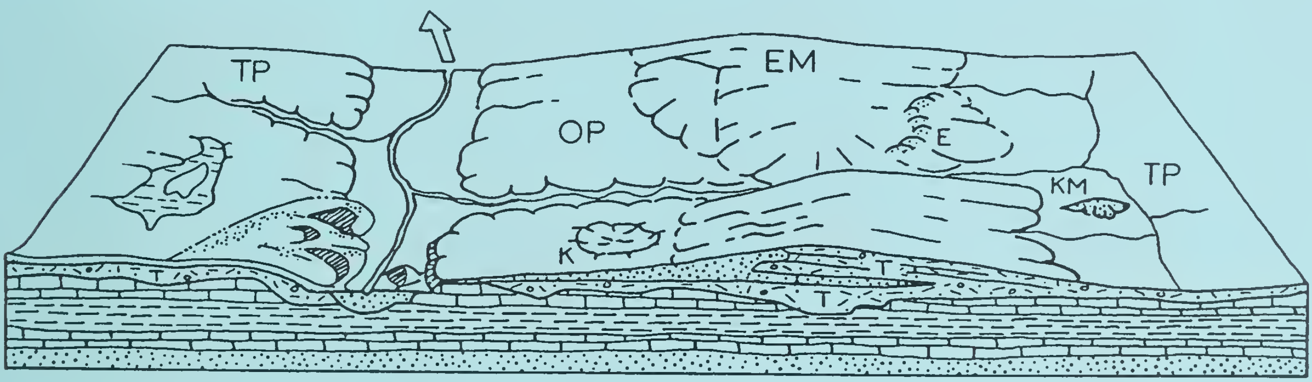
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

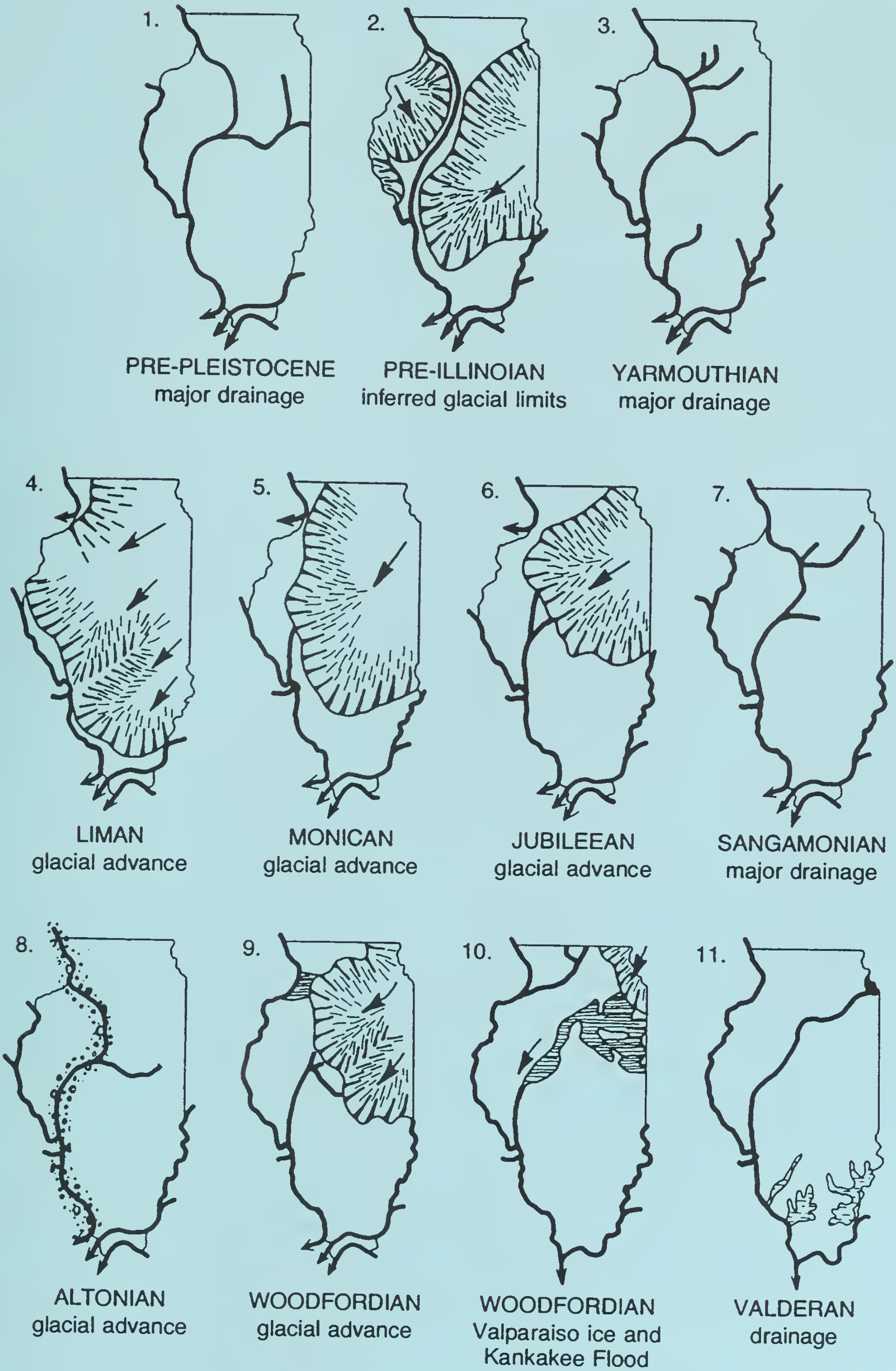
TIME TABLE OF PLEISTOCENE GLACIATION

			STAGE		SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY			HOLOCENE (interglacial)		Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
					10,000		
	Pleistocene		WISCONSINAN (glacial)	late	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
					11,000		
					Twocreekan	Peat and alluvium	Ice withdrawal, erosion
					12,500		
					Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
					25,000		
				mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
					28,000		
				early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
					75,000		
			SANGAMONIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
					125,000		
			ILLINOIAN (glacial)		Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
					Monican	Drift, loess, outwash	
					Liman	Drift, loess, outwash	
					300,000?		
			YARMOUTHIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
					500,000?		
		Pre-Illinoian	KANSAN* (glacial)			Drift, loess	Glaciers from northeast and northwest covered much of state
					700,000?		
			AFTONIAN* (interglacial)			Soil, mature profile of weathering	(hypothetical)
					900,000?		
			NEBRASKAN* (glacial)			Drift (little known)	Glaciers from northwest invaded western Illinois
					1,600,000 or more		

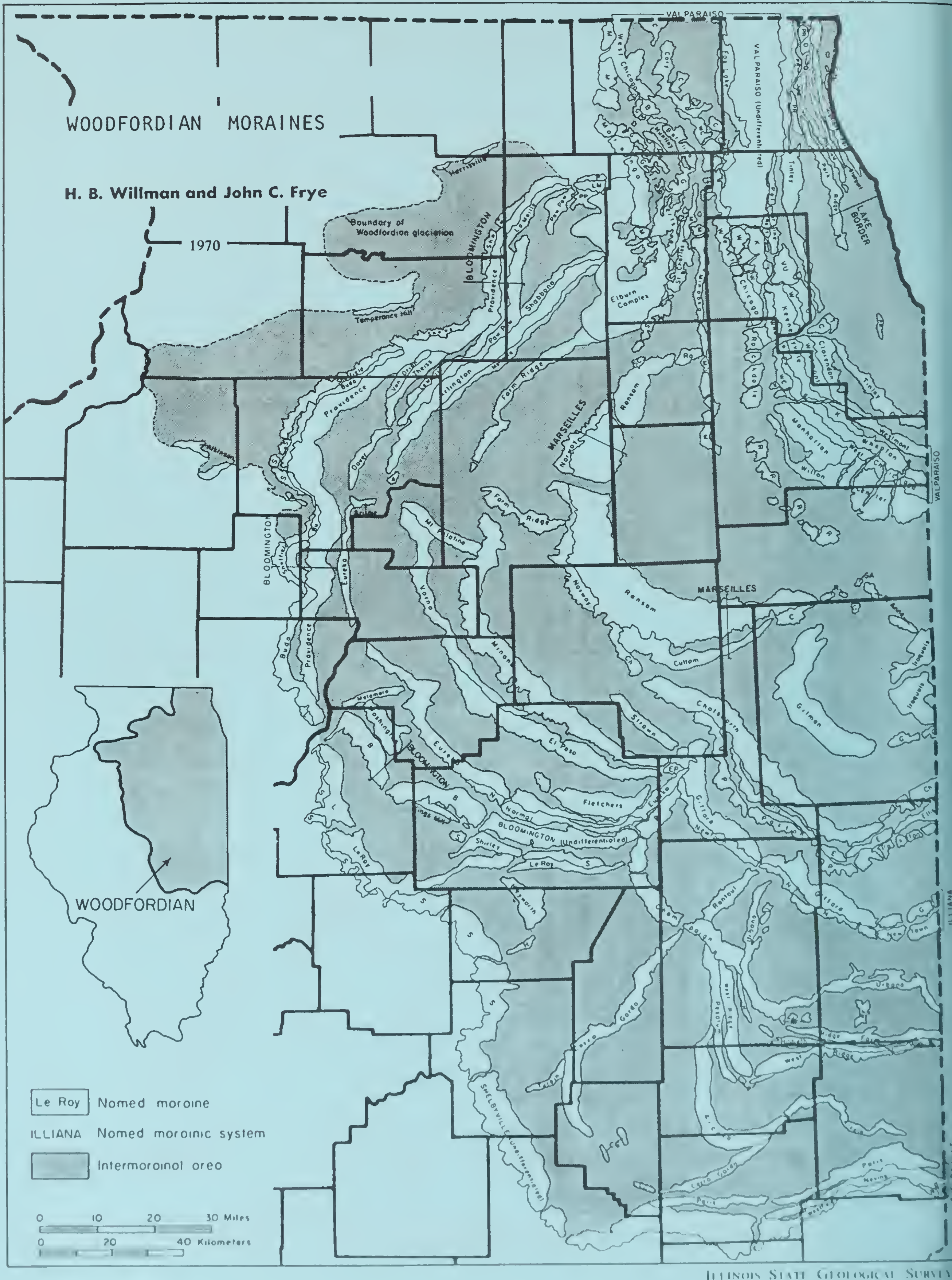
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
MARSEILLES
BLOOMINGTON (Undifferentiated)
SHELBYVILLE (Undifferentiated)
ILLIANA
Elburn Complex
Temperance Hill
Providence
Shabbona
Farm Ridge
Ransom
Manhattan
Wilton
Minonk
Varna
Eureka
El Paso
Chatsworth
Cullom
Gilman
Iroquois
Fletchers
Normal
Shirley
Le Roy
Rantoul
Urbana
West Ridge
Cerro Gordo
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

ILLINOIS STATE GEOLOGICAL SURVEY

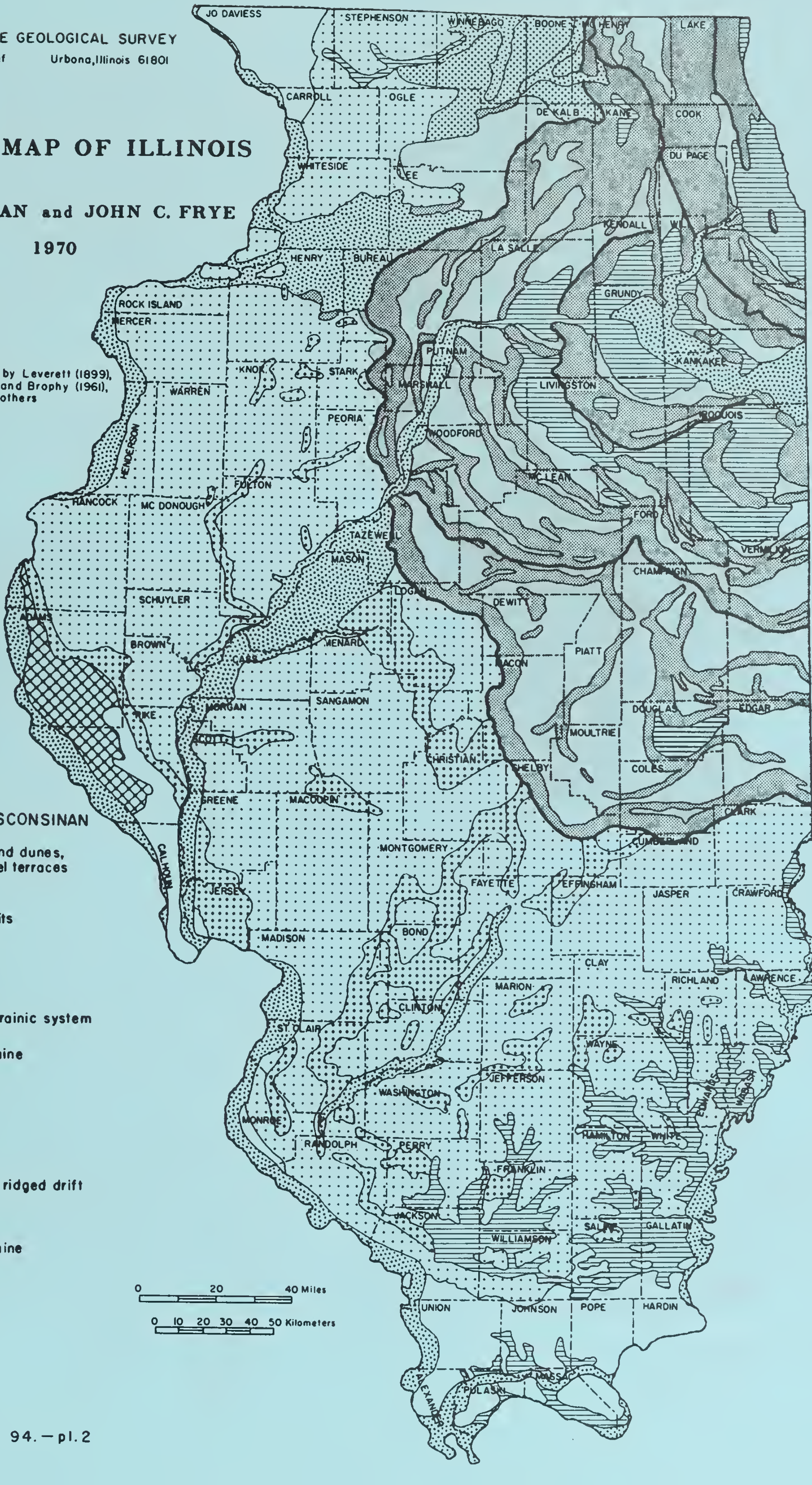
John C. Frye, Chief   Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

Groundmoraine

KANSAN

Till plain

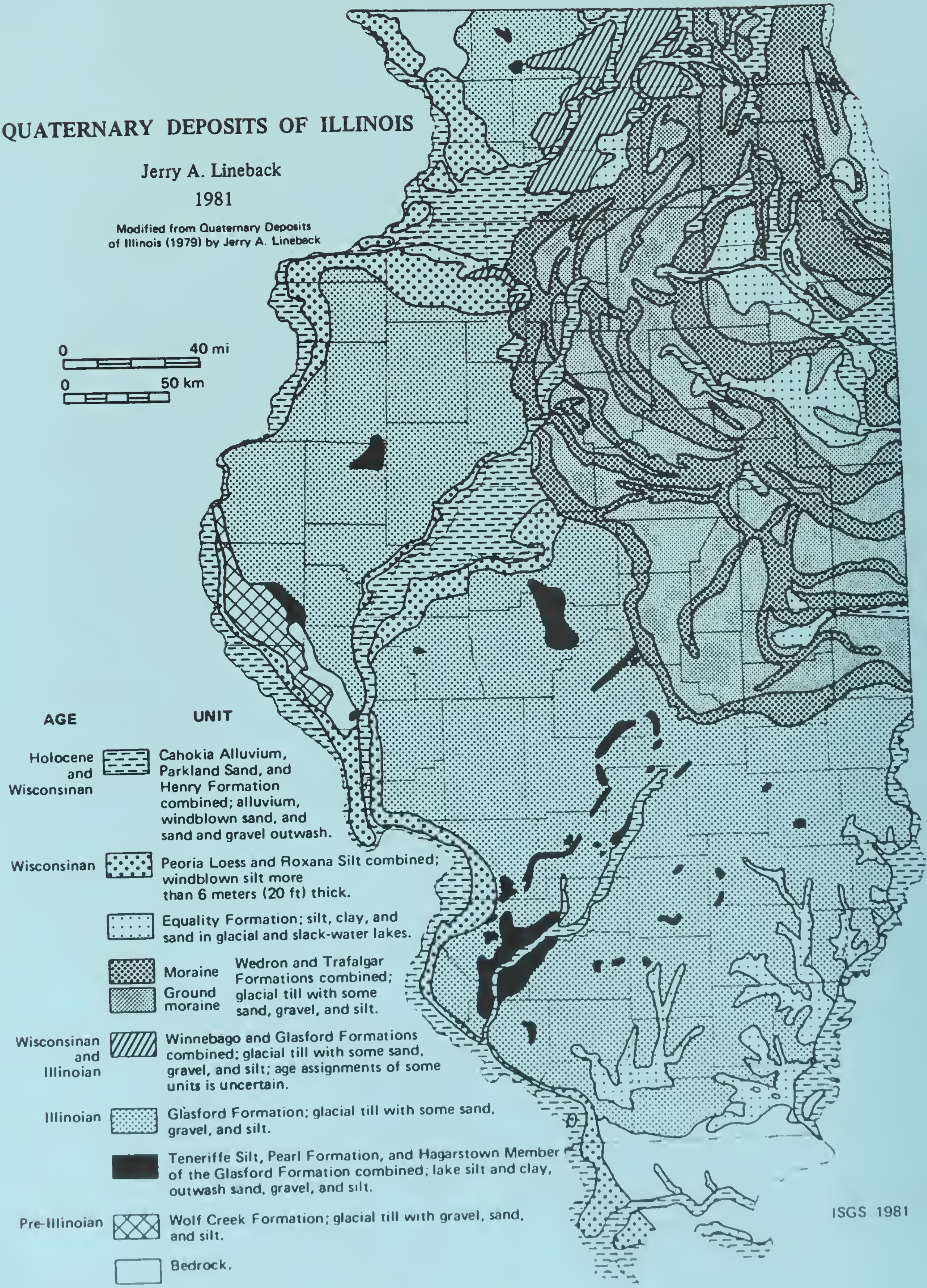
DRIFTLESS

Modified from Bull. 94.—pl.2

QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback
1981

Modified from Quaternary Deposits of Illinois (1979) by Jerry A. Lineback



DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

At the close of the Mississippian Period, about 310 million years ago, the sea withdrew from the Midcontinent region. A long interval of erosion that took place early in Pennsylvanian time removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. Ancient river systems cut deep channels into the bedrock surface. Later, but still during early Pennsylvanian (Morrowan) time, the sea level started to rise; the corresponding rise in the base level of deposition interrupted the erosion and led to filling the valleys in the erosion surface with fluvial, brackish, and marine sands and muds.

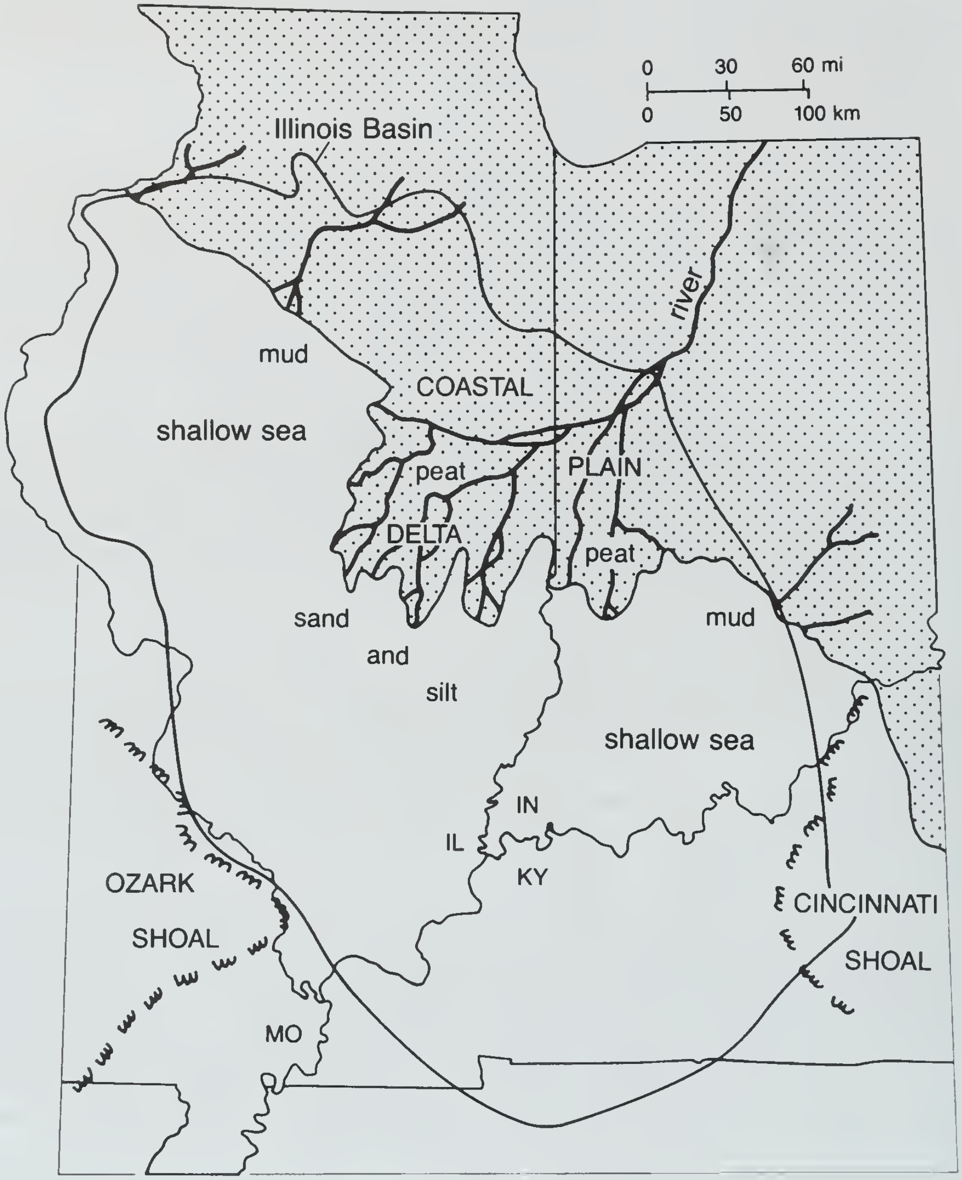
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed thin but widespread deltas that coalesced into a vast coastal plain or lowland that prograded (built out) into the shallow sea that covered much of present-day Illinois (see paleogeographic map, next page). As the lowland stood only a few feet above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline.

During most of Pennsylvanian time, the Illinois Basin gradually subsided; a maximum of about 3000 feet of Pennsylvanian sediments are preserved in the basin. The locations of the delta systems and the shoreline of the resulting coastal plain shifted, probably because of worldwide sea level changes, coupled with variation in the amounts of sediments provided by the river system and local changes in basin subsidence rates. These frequent shifts in the coastline position caused the depositional conditions at any one locality in the basin to alternate frequently between marine and nonmarine, producing a variety of lithologies in the Pennsylvanian rocks (see lithology distribution chart).

Conditions at various places on the shallow sea floor favored the deposition of sand, lime mud, or mud. Sand was deposited near the mouths of distributary channels, where it was reworked by waves and spread out as thin sheets near the shore. Mud was deposited in quiet-water areas — in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Limestone was formed from the accumulation of limy parts of plants and animals laid down in areas where only minor amounts of sand and mud were being deposited. The areas of sand, mud, and limy mud deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sand, mud, and lime mud were deposited on the coastal plain bordering the sea. The nonmarine sand was deposited in delta distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies 100 or more feet thick were deposited in channels that cut through the underlying rock units. Mud was deposited mainly on floodplains. Some mud and freshwater lime mud were deposited locally in fresh-water lakes and swamps.

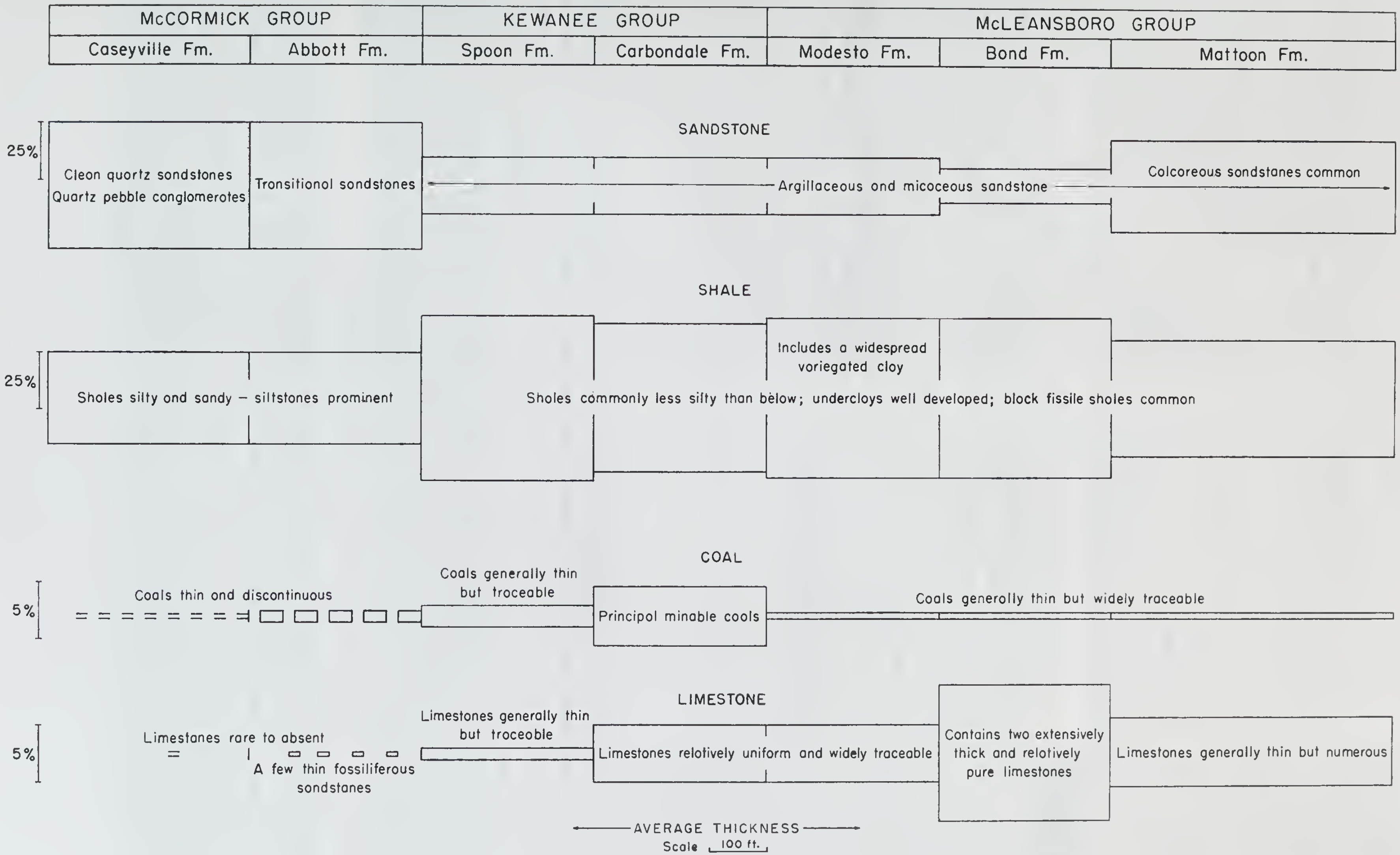
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath the coal is not precisely known, most evidence indicates that they were deposited in the swamps as slackwater mud before the accumulation of much plant debris. The clay underwent modification to become the soil upon which the lush vegetation grew in the swamps. Underclay frequently contains plant roots and rootlets that appear to be in their original places. The vast swamps were the culmination of nonmarine deposition. Resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were laid down over the peat.



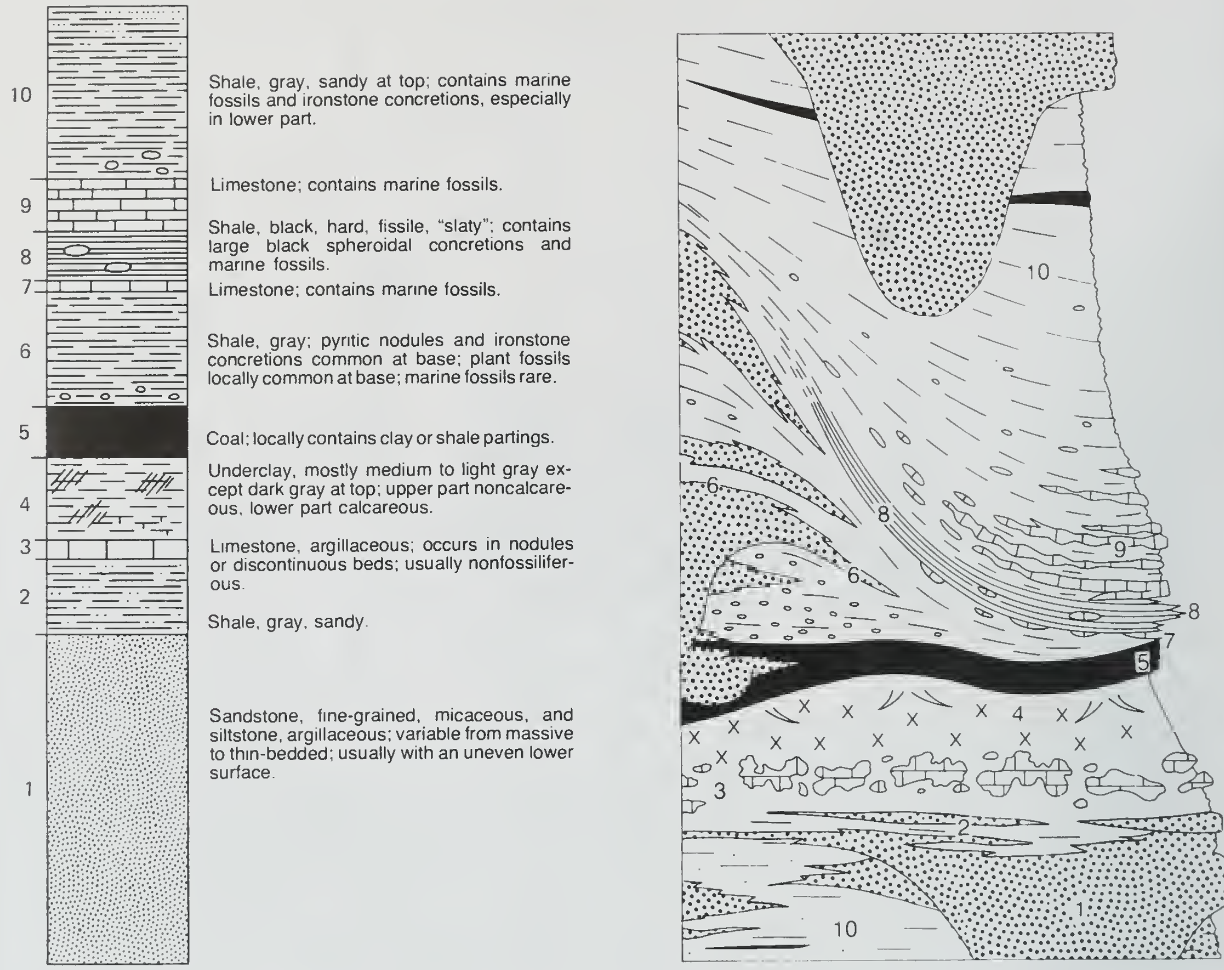
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

The Pennsylvanian strata exhibit extraordinary variations in thickness and composition both laterally and vertically because of the extremely varied environmental conditions under which they formed. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and some limestones, however, display remarkable lateral continuity for such thin units. Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.



General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.



The idealized cyclothem at left (after Willman and Payne, 1942) infers continuous, widespread distribution of individual cyclothem units, at right the model of a typical cyclothem (after Baird and Shabica, 1980) shows the discontinuous nature of many units in a cyclothem.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting shoreline. Each series of alternations, called a cyclothem, consists of several marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an "ideally" complete cyclothem consists of ten sedimentary units (see illustration above contrasting the model of an "ideal" cyclothem with a model showing the dynamic relationships between the various members of a typical cyclothem).

Approximately 50 cyclothems have been described in the Illinois Basin but only a few contain all ten units at any given location. Usually one or more are missing because conditions of deposition were more varied than indicated by the "ideal" cyclothem. However, the order of units in each cyclothem is almost always the same: a typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal-gray shale portion (the lower six units) of each cyclothem is nonmarine: it was deposited as part of the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal and gray shale are marine sediments deposited when the sea advanced over the coastal plain.

Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothems. The swamps occupied vast areas of the coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm, humid Pennsylvanian climate. (Illinois at that time was near the equator.) The deciduous trees and flowering plants that are common today had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate (tropical). Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

Plant debris from the rapidly growing swamp forests — leaves, twigs, branches, and logs — accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented oxidation, and any decay of the peat deposits was due primarily to bacterial action.

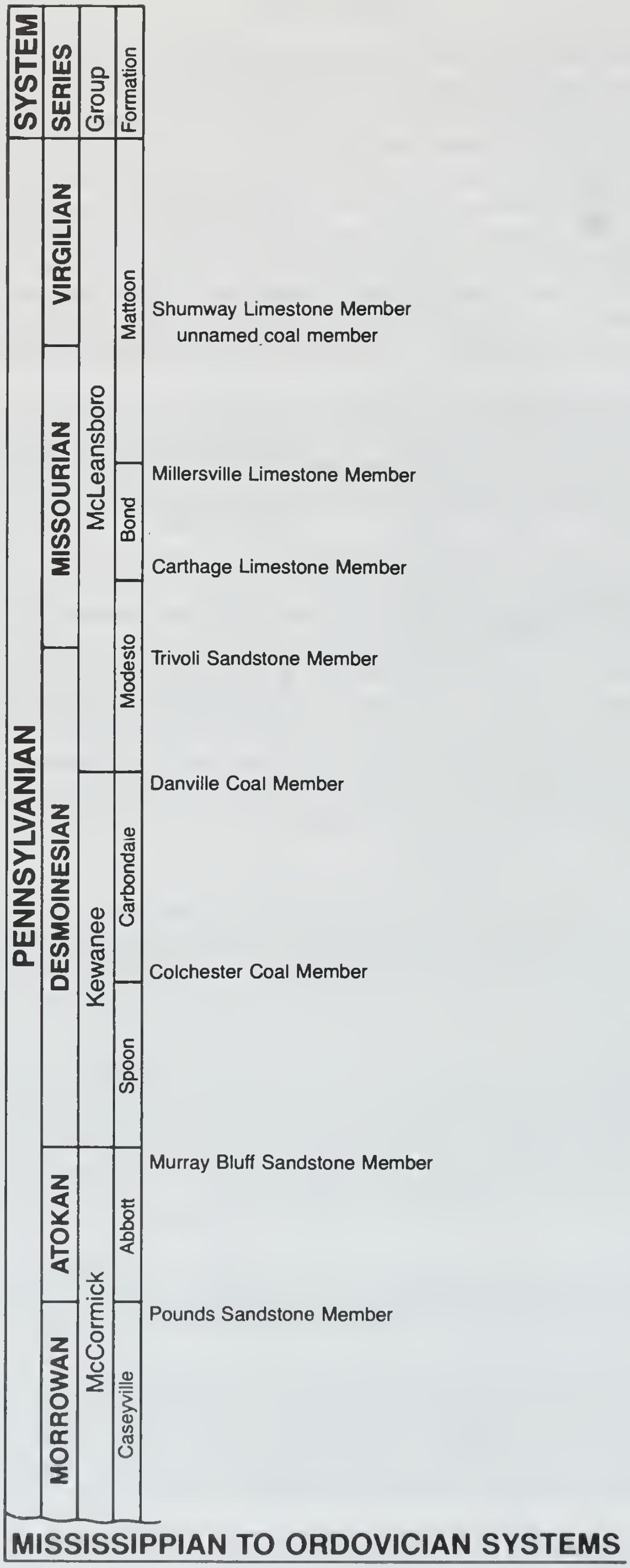
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even the marine sediments being deposited on the top of the drowned peat contained various minerals in solution, including sulfur, which further infiltrated the peat. As a result, the peat developed into a coal that is high in sulfur. However, in a number of areas, nonmarine muds, silts, and sands from the river system on the coastal plain covered the peat where flooding broke through levees or the river changed its coarse. Where these sediments (unit 6 of the cyclothem) are more than 20 feet thick, we find that the coal is low in sulfur, whereas coal found directly beneath marine rocks is high in sulfur. Although the seas did cover the areas where these nonmarine, fluvial sediments covered the peat, the peat was protected from sulfur infiltration by the shielding effect of these thick fluvial sediments.

Following burial, the peat deposits were gradually transformed into coal by slow physical and chemical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coal-forming ("coalification") process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich



Generalized stratigraphic column of the Pennsylvanian in Illinois (1 inch = approximately 250 feet).

mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.

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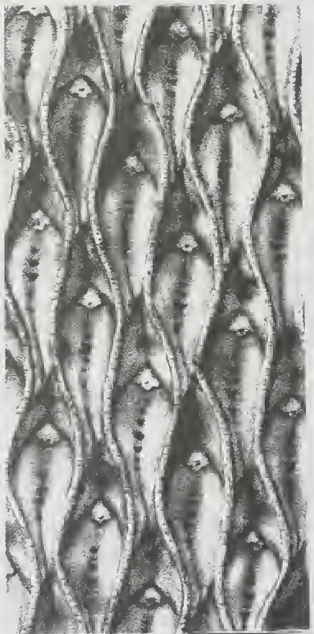
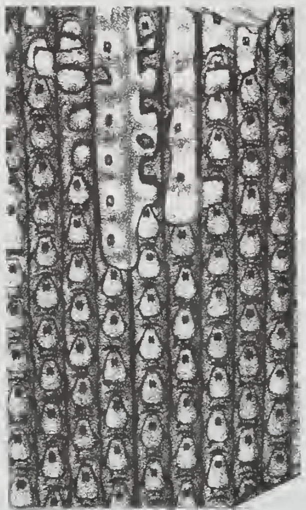
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



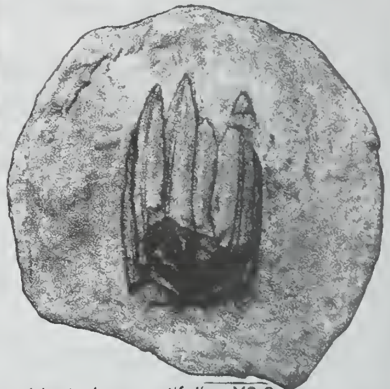
Lepidodendron aculeatum X0.8

Lepidophloios laricinus X0.63

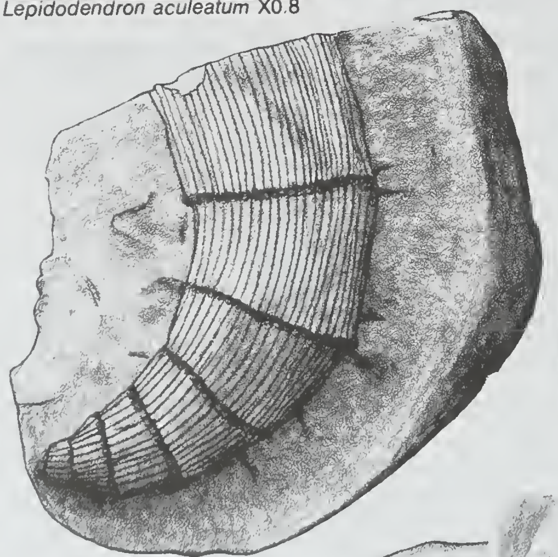


Sigillaria mammilaris X0.5

Stigmaria ficoides X0.32



Lepidostrobus ovatifolius X0.8



Calamites suckowii X0.5

Annularia stellata X0.63

Sphenophyllum cuneifolium X0.4

Pecopteris sp. X0.32

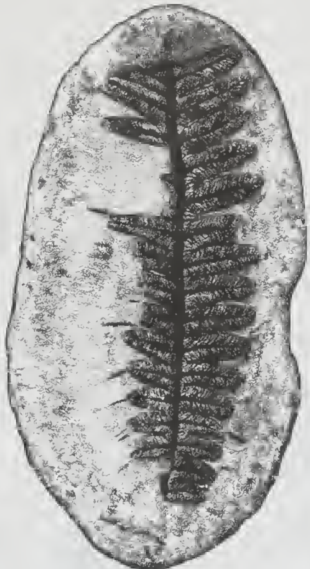
Pecopteris miltonii X2.0

Pecopteris hemitelioides X1.0

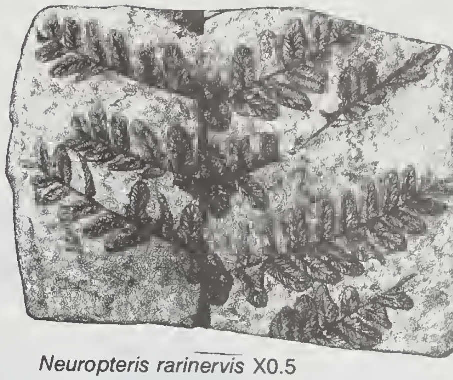
J. R. Jennings, ISGS

Common Pennsylvanian plants: seed ferns and cordaiteans

Alethopteris serlii X0.63



Alethopteris ambigua X0.63

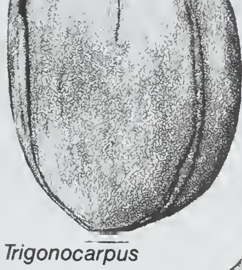


Neuropteris rarinervis X0.5

Mariopteris nervosa X0.8

Neuropteris scheuchzeri X0.63

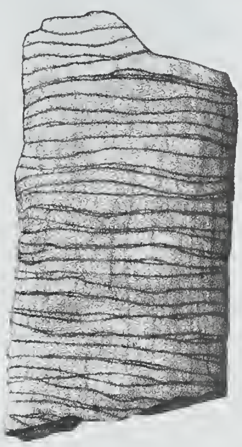
Sphenopteris rotundiloba X0.8



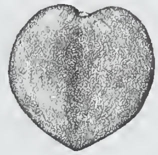
Trigonocarpus parkinsonii X1.25

Cordaites principalis X0.63

Cordaicladus sp. X1.0



Artisia transversa X0.63



Cordaicarpon major X2.0

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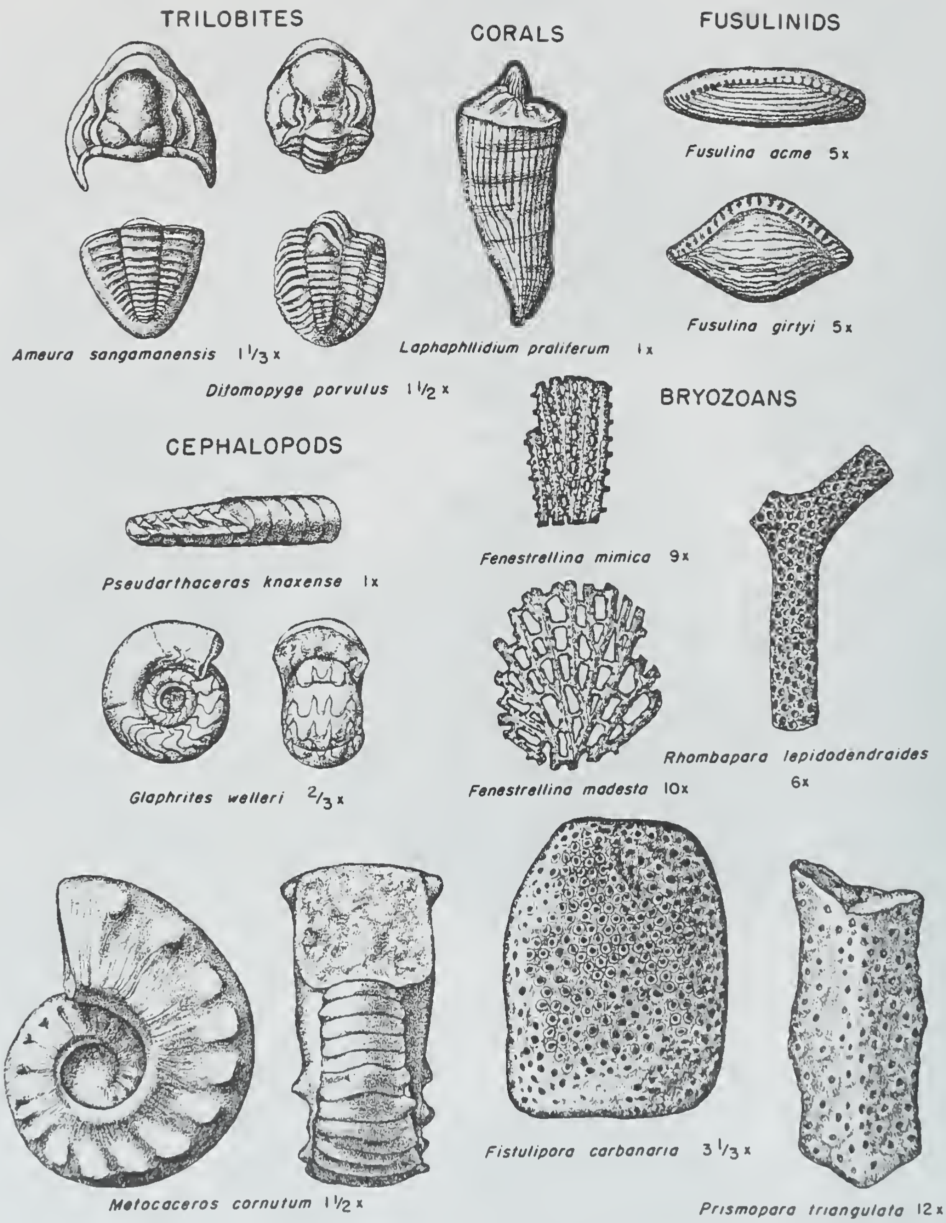
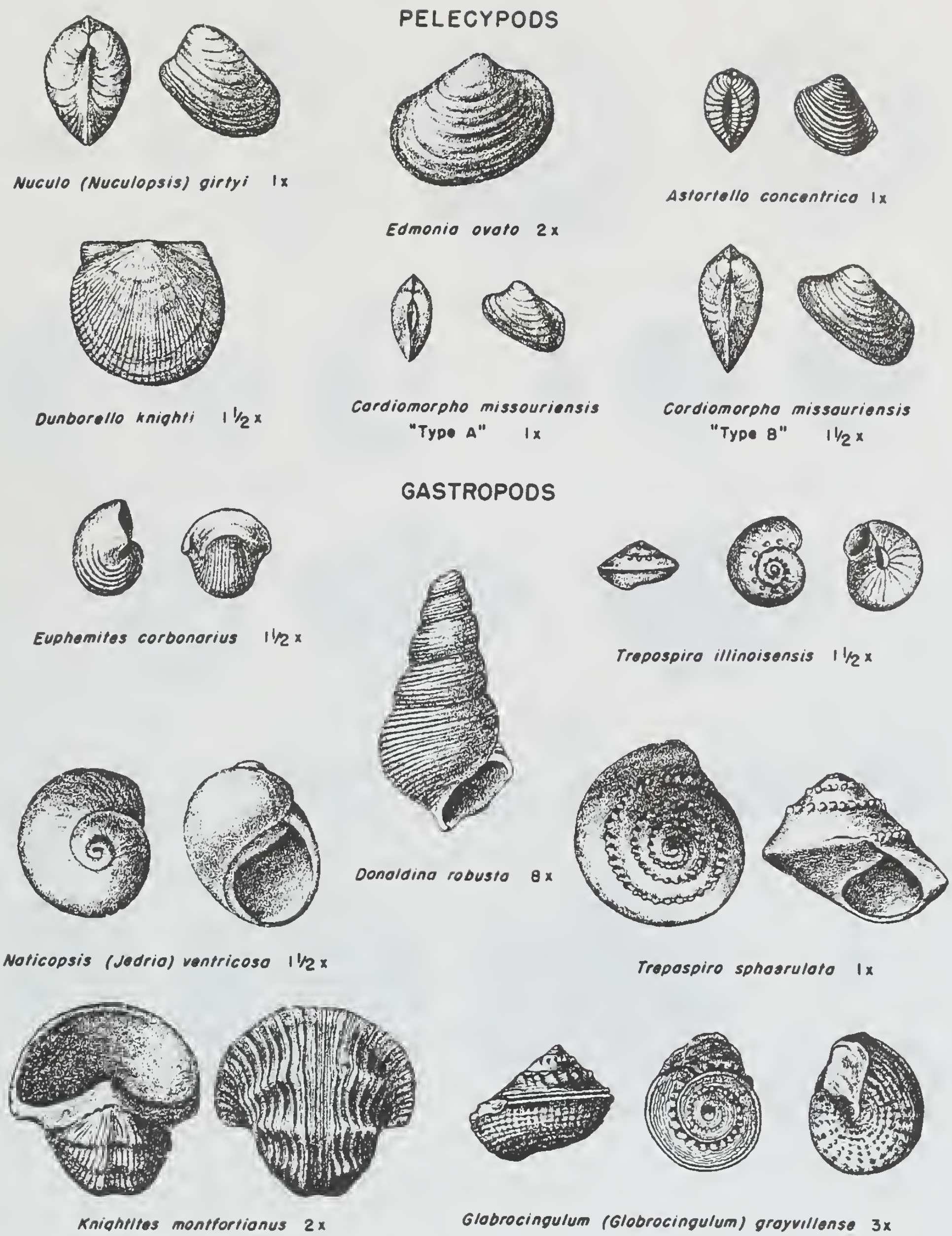
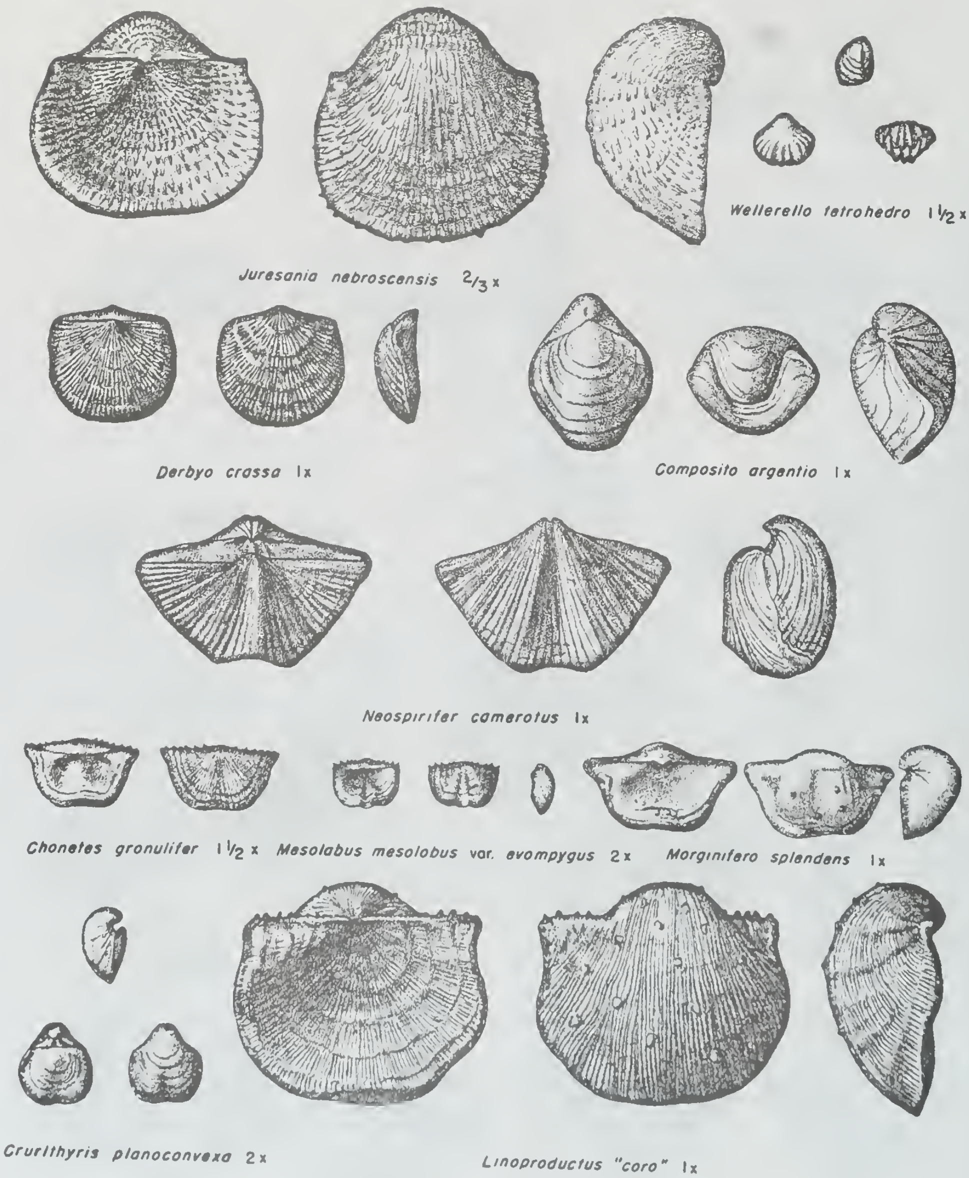
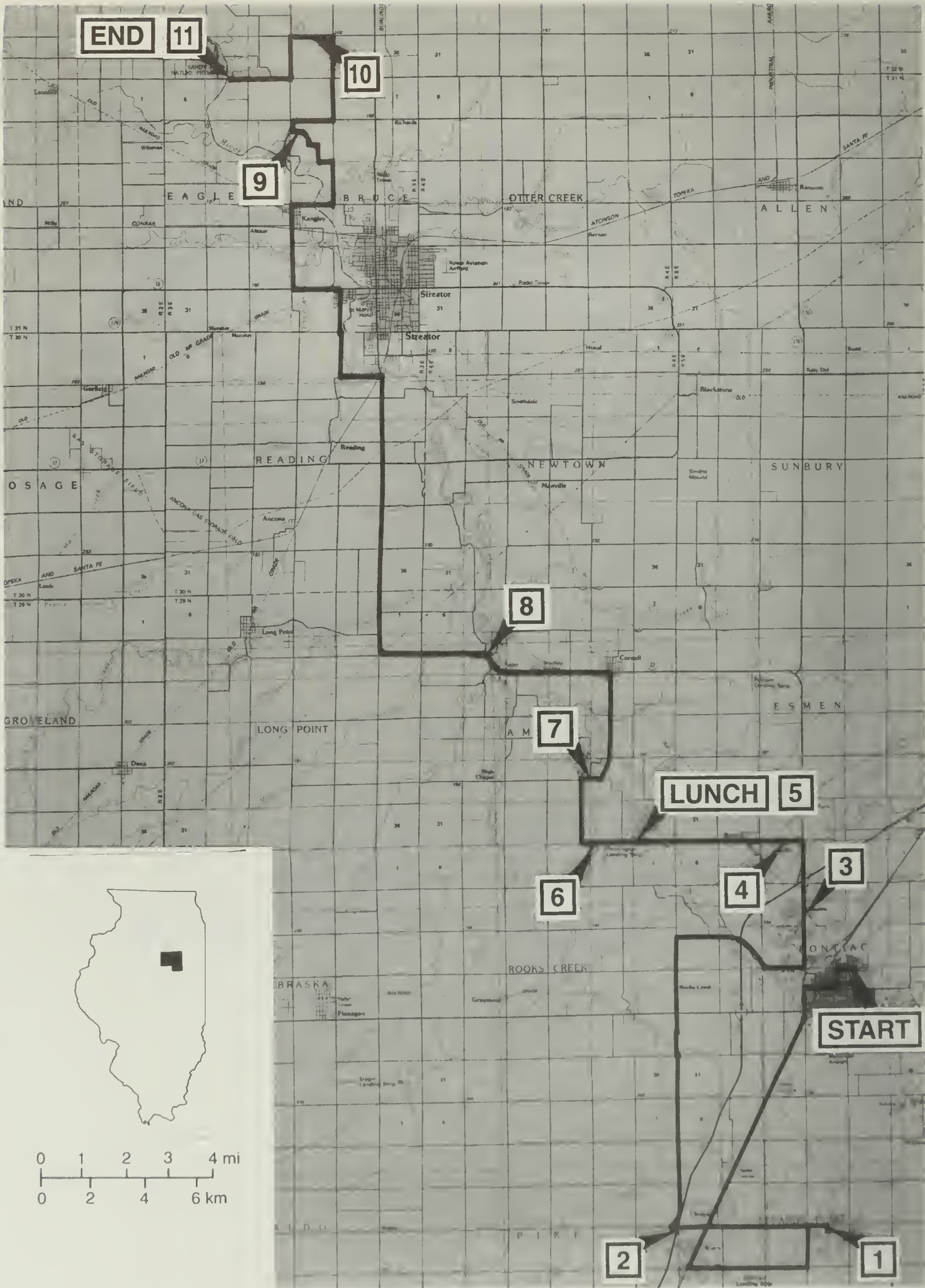

TRILOBITES
CORALS
FUSULINIDS
Fusulina acme 5x
Fusulina girtyi 5x
Ameura sangamanensis 1 1/3 x
Laphaphllidium praliferum 1x
Ditomopyge porvulus 1 1/2 x
BRYOZOANS
CEPHALOPODS
Pseudarthaceras knaxense 1x
Fenestrellina mimica 9x
Glaphrites welleri 2/3 x
Fenestrellina madesta 10x
Rhombapara lepidodendraides 6x
Metacaceras cornutum 1 1/2 x
Fistulipora carbanaria 3 1/3 x
Prismopara triangulata 12x


PELECYPODS
Nucula (Nuculopsis) girtyi 1x
Edmonia ovata 2x
Astartella concentrica 1x
Dunbarella knighti 1 1/2 x
Cardiomorpha missouriensis "Type A" 1x
Cardiomorpha missouriensis "Type B" 1 1/2 x
GASTROPODS
Euphemites carbonarius 1 1/2 x
Trepospira illinoisensis 1 1/2 x
Donaldina robusta 8x
Naticopsis (Jedria) ventricosa 1 1/2 x
Trepospira sphaerulata 1x
Knightites montfortianus 2x
Glabrocingulum (Glabrocingulum) grayvillense 3x

BRACHIOPODS





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ALLEN
READING
NEWTOWN
SUNBURY
OSAGE
GROVELAND
LONG POINT
ESMEN
BROOKS CREEK
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PIKE
Streator
PONTIAC
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0 2 4 6 km